Power and The Engineer

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PRACTICAL ability undoubtedly is a grand thing and very valuable.

A man could read his eyes out on the subject, "How to be a Successful Swimmer," and yet drown like a rat in a submerged trap if he should attempt to put his theoretical or "book" knowledge into practice in any but shoal water.

The sane man does not live who would be willing to try to "turn the trick" in deep water.

Further, if a man could be induced to try, beyond the shadow of a doubt he would fail miserably no matter how hard he had studied to succeed. He would not have the knack and self-confidence necessary to make good.

The same thing applies, in variable degree, to practically every operation involving manual skill.

Take, for instance, the fairly simple "stunt" of stopping an engine, the novice—nervous and overanxious—would botch the job in the majority of cases. Yet, what little there is that could be written about the task could be learned in a very short time.

On the other hand, there are some things which, though easy to learn, are of little value to the performer unless he possesses an amount of theoretical or "reason-why" knowledge, such as is required to indicate an engine intelligently.

The average man could learn to take a diagram perfectly in a few hours. But—he could indicate engines "till the bench broke" and be but very little better off and no more valuable to himself or others unless he knew what the diagrams showed and could adjust the engines to operate more satisfactorily.

The theoretical part of the equipment which a first-class engineer must have is by far the more difficult to acquire.

There is no denying that systematic study is something of a hardship for most mortals.

There is no royal road to knowledge. The expenditure of money alone will not purchase the "right of way". Mental effort is required and perseverance as well.

That the efforts so directed secure handsome rewards is corroborated by the brilliant careers of countless men made possible simply because these men were given to the study habit.

Methodical study serves to discipline the mind and assist it to acquire the ability to reason. And reasoning is the highest type of mental activity and probably the rarest.

Have you the study habit?

If not, ask yourself, Why not?

It is never too late to learn!

Some Important Furnace Alterations

By A. D. Blake

By extending the furnace 30 inches the maximum capacity of each boiler was increased from 750 to 1000 horsepower. The changes necessitated the substitution of a suspended arch in place of the usual form of sprung arch.

Some interesting developments in furnace practice have taken place recently at the Long Island City power house of the Pennsylvania railroad. This plant is the central station which furnishes power for the electric trains of the Long Island railroad and for those of the Pennsylvania railroad's recent extension into New York City, which includes the tubes under both the Hudson and the East rivers.

The original installation included thirty-two Babcock & Wilcox boilers each, including superheaters, having a rated capacity of 650 horsepower and a maximum of about 750 horsepower, the rated capacity being based upon 10 square feet of heating surface per boiler horsepower. These furnished steam to three 5500-kilowatt Westinghouse-Parsons turbines which carried the train load for the Long Island railroad. To meet the increased demands for power subsequent to the extension of the Pennsylvania railroad it was decided to install four additional units, two of 8000 and two of 3000 kilowatts capacity. This required more boiler capacity, but instead of increasing the number of boilers, the capacities of those already installed were increased. Accordingly, the grate area of each boiler was enlarged 20 per cent. by extending the furnace 30 inches in front and giving it a dutch-oven effect. Also, the Roney stokers were replaced by larger ones of the same kind, but having the improved form of grate. By this means the working capacity of each boiler was increased to about 1000 horsepower.

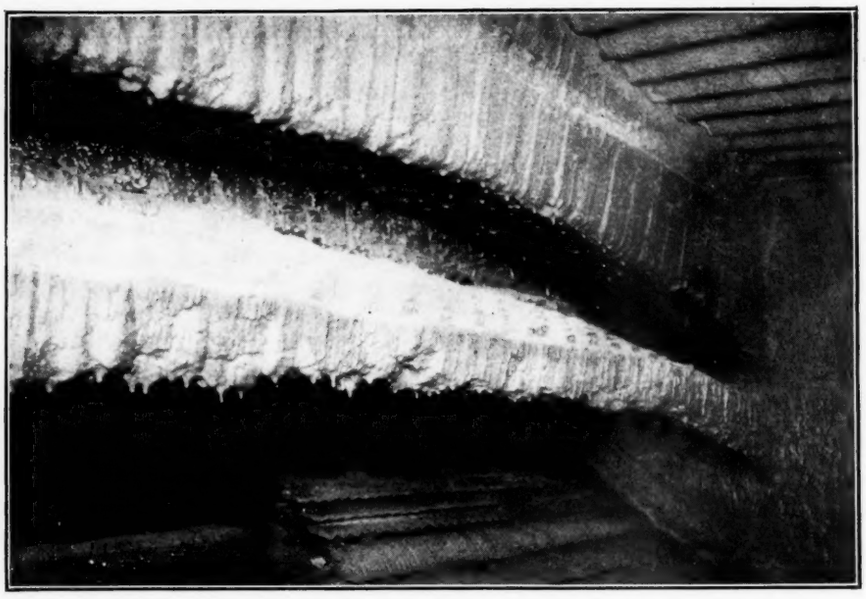


FIG. 1. FAILURE OF SPRUNG ARCH UNDER EXCESSIVE TEMPERATURE

These furnace changes, however, involved certain difficulties. By extending the furnace fronts, in many cases a steel building column was brought directly within the fire space. To prevent overheating, each column was inclosed within a cast-iron casing, between which there is considerable air space, and the latter was sheathed with asbestos board, which, in turn, was protected by firebrick. Measurements taken in the air space surrounding the columns have shown that this method of protecting the columns from the heat of the fire is entirely adequate.

The second difficulty encountered was due more directly to the new type of grate. In this the slots between adjacent fuel plates allow much more air to pass through the fire than with the old type, hence a much hotter fire results. As a consequence, it was soon discovered that the sprung firing arches would not hold up for any length of time under the increased temperatures but began to fuse and fall as shown in Fig. 1.

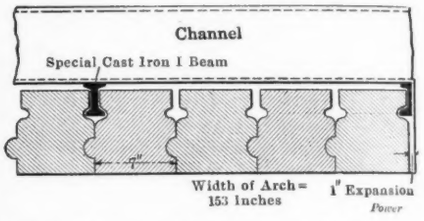


FIG. 3. METHOD OF SUSPENDED FLAT ARCH

The engineers accordingly set about to devise a means for overcoming this trouble and finally decided upon installing a suspended arch in place of the regular

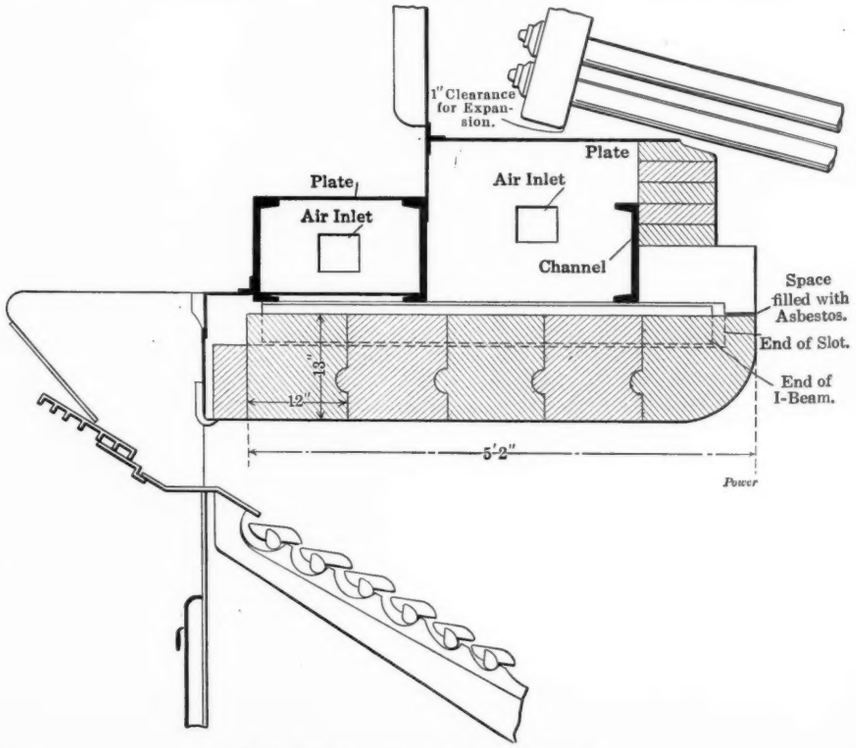


FIG. 2. SECTION THROUGH FURNACE

sprung arch. This is a straight arch made up of especially formed tile hung from special cast-iron I-beams. The latter are prevented from becoming overheated by the circulation of air through spaces over the arch, the air entering through rectangular holes in the sides of the boiler setting. It has been found that, even when forcing, the temperature of these supporting beams is not excessive. Some of these new arches have been in service since last February and have held up remarkably well. Fig. 2 is a cross-section through the furnace showing the arrangement of the new arches and the air space above, while Fig. 3 shows how the tile blocks fit over the I-beams. In Fig. 4 is shown one of these arches shortly after being installed.

Bituminous coal is used, having a heat value of 14,500 B.t.u. and an average composition of,

	Per Cent.
Volatile matter	18.50
Ash	8
Sulphur	1.75
Moisture	1.50
Carbon	70.25

Natural draft is employed with steel stacks 275 feet high, and when running at maximum capacity with a draft of 5/8 inch of water over the fire and 1 inch at the base of the stack, as high as 45 pounds of coal have been burned per square foot of grate surface per hour.

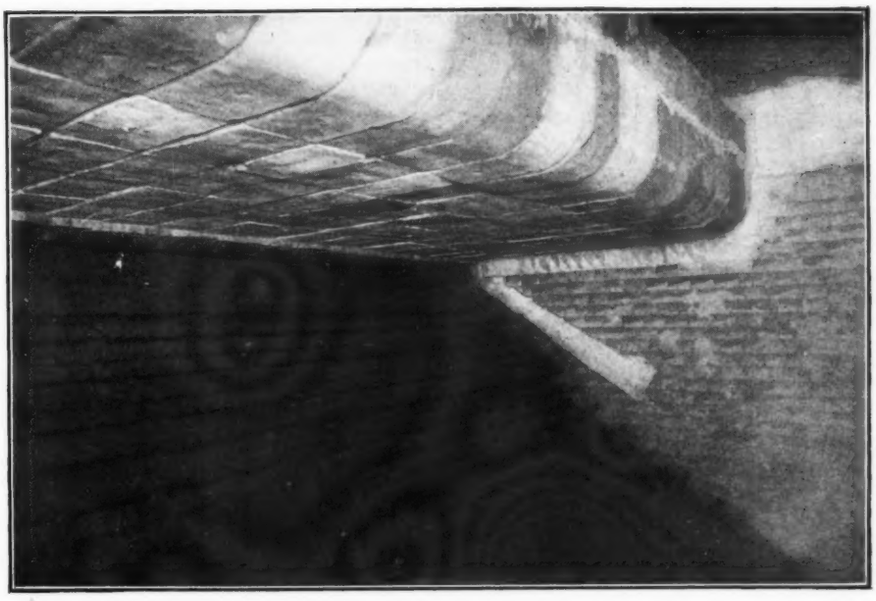


FIG. 4. ONE OF THE NEW ARCHES IN PLACE

An interesting fact in connection with the furnace changes is brought out by an examination of the results of the flue-gas analyses, these showing a marked increase of CO_2 with the new arches and stokers. The average for a number of samples taken before the changes were made showed 13.9 per cent. of CO_2 and the average for the same number of samples taken after the changes were effected showed 14.9 per cent. of CO_2, a gain of 1 per cent.

Graphite and Its Manufacture

By James J. Jenkins

To clear up misconceptions that have long existed about graphite the author tells of the great uses found for it in the fields of lubrication, electrochemistry and elsewhere.

Carbon is one of the most mysterious elements with which man has to deal. Diamond, lampblack and graphite are three allotropic forms of this element and it is very difficult to find an explanation of the difference between these three forms. Still, it is known that there is a very great difference.

Graphite has been known to humanity since the latter part of the fourteenth century. Excavations which opened graves of the ancients brought to light knowledge that they knew of some of the properties of graphite, but they left no record of their understanding. It seems that their recognition of its true nature was very slow, possibly because they had little need for a mineral possessing its properties. In reviewing the history of graphite, it is somewhat astonishing to learn that even to this day it is associated in some minds with lead as being "Black Lead" or "Plumbago," which names might very well have been discarded away back in 1779 when Karl Wilhelm Scheele, of Kopen, Sweden, learned the true chemical nature of graphite, or before that date when Heinrick Pott, a German chemist, demonstrated that graphite contains no lead. Considering the present-day use of graphite in making lead pencils, it is very clear that this form of carbon is well named "Graphite," a word taken from the Greek and which means "I write."

It is probable that the diamond has always had more in it of general interest than graphite, but, considering the extended variety of present-day uses of graphite and the service it renders the world in many fields, there can be no question which of these two forms of carbon is of the highest intrinsic value. The diamond, in its sparkling clearness, is fascinating in the extreme, especially when it graces the hair, neck or hand of an engineer's wife, daughter or other loved one, but the faithful engineer who day after day and year after year battles with his chief foe—Friction—is well aware that the black, lusterless form of carbon, known as graphite, is his true friend at those times when he needs an efficient lubricant.

While graphite has been known to man for centuries, it is worthy of note that in 1909 we passed the fiftieth anniversary of the drilling of the first petroleum oil well by Colonel Drake on Oil creek, Penn. Up to that time, the world depended upon sperm oil, lard oil and a few other mediums for its lubricants. It is certain, considering the great modern installation of machinery, that engineers would find it impossible to return to these methods of lubrication. Today the world is in full appreciation of petroleum oils and greases as lubricants.

It has been said that the life of the supply of petroleum oils is less than the years allotted to man, which is three score and ten. Assuming this conclusion to be correct, it is evident that unless a lubricant be found competent to take the place of this oil, the industrial world must stop; the great factories must cease to operate. Transcontinental and other trains must cease to run and the great steamships will no longer speed across the ocean. Lubrication is so essential that it is appalling to consider the results which would surely develop if the world were not provided with a lubricant of equal or greater merit, for, even if the supply were sufficient, it would be utterly impossible for man to operate his great modern installations of machinery with the crude lubricants of years ago. Man accepted petroleum oil and oil products as an advance over sperm-oil lubrication, a fact which should make it easier

for him to realize that in graphite, as it is today available, he has at his command a lubricant which, it would seem, is destined to be a lubricant of future time and ages, inasmuch as the supply can be made such as to meet all present and future demands.

We are coming to know more about graphite and its value every day. In the *Scientific American* there was an account of a new form of graphite that is very fluffy and of a greatly expanded nature, which graphite is said to have been developed from the so called crystalline graphite, in its new form lacking the luster of the flake and being extremely fine. There are graphite mines in Austria, Bavaria, Ceylon, Canada, England, Italy, Mexico, Siberia, the United States and other countries, and scientists have found that meteorites which have dropped to earth out of the sky, both in this country and in Europe, brought graphite with them. Many tons of graphite are imported annually by the United States, indications being that the consumption is on the increase. The presence of all of these deposits indicates that nature was very generous in her distribution of this mineral. She made it in two varieties, as we understand them, one of which is amorphous; the other is the so called crystalline variety. Generally speaking, graphite has a world of uses, and there are many applications where it is still used as "Black Lead" or "Plumbago."

And now, man has learned how to make graphite, a fact which supports the conclusion that destiny is working itself out and that, having gained this knowledge, man has simply placed himself in a position to meet the requirements of the consumption of this mineral as its value becomes better known. This conclusion is based on the supposition that as the world grows, as it progresses, there is revealed a way whereby men may assist one another with their knowledge for the general good of all mankind. It is not known how or when nature made graphite. Man makes it by the application of tremendous temperatures to raw materials he places in an electrically operated furnace. Nature has no choice of raw materials whereas man is more fortunate, having the world from which to select his.

In the electric-furnace process it has been found possible to impart certain definite chemical and physical properties to the graphite made. This product may be in the form of rods, tubes or plates, for use as electrodes or as lump graphite, this latter to be ground later to the form of impalpable powder for use in the various fields which it enters.

Not only has man learned how to make graphite that is practically chemically pure, but he has gone further into the art and invented a process whereby graphite is "deflocculated," as the inventors call it, signifying the supposed breaking asunder of the compound particles into the smallest particles in which the substance can exist while retaining its identity. Whether or not the graphite is reduced to the molecular or collodial state, it will remain suspended in oil or water, and passes with it through fine filtering paper. This process marks a very notable advance in the application of graphite to the field of lubrication and is that modern process above referred to as developing a modern lubricant for modern machinery.

In the first 50 years of the use of petroleum oils as lubricants, the warning was sounded that it is necessary to conserve the world's resources in this field. Man was never without the facilities of accomplishing those things the most pro-

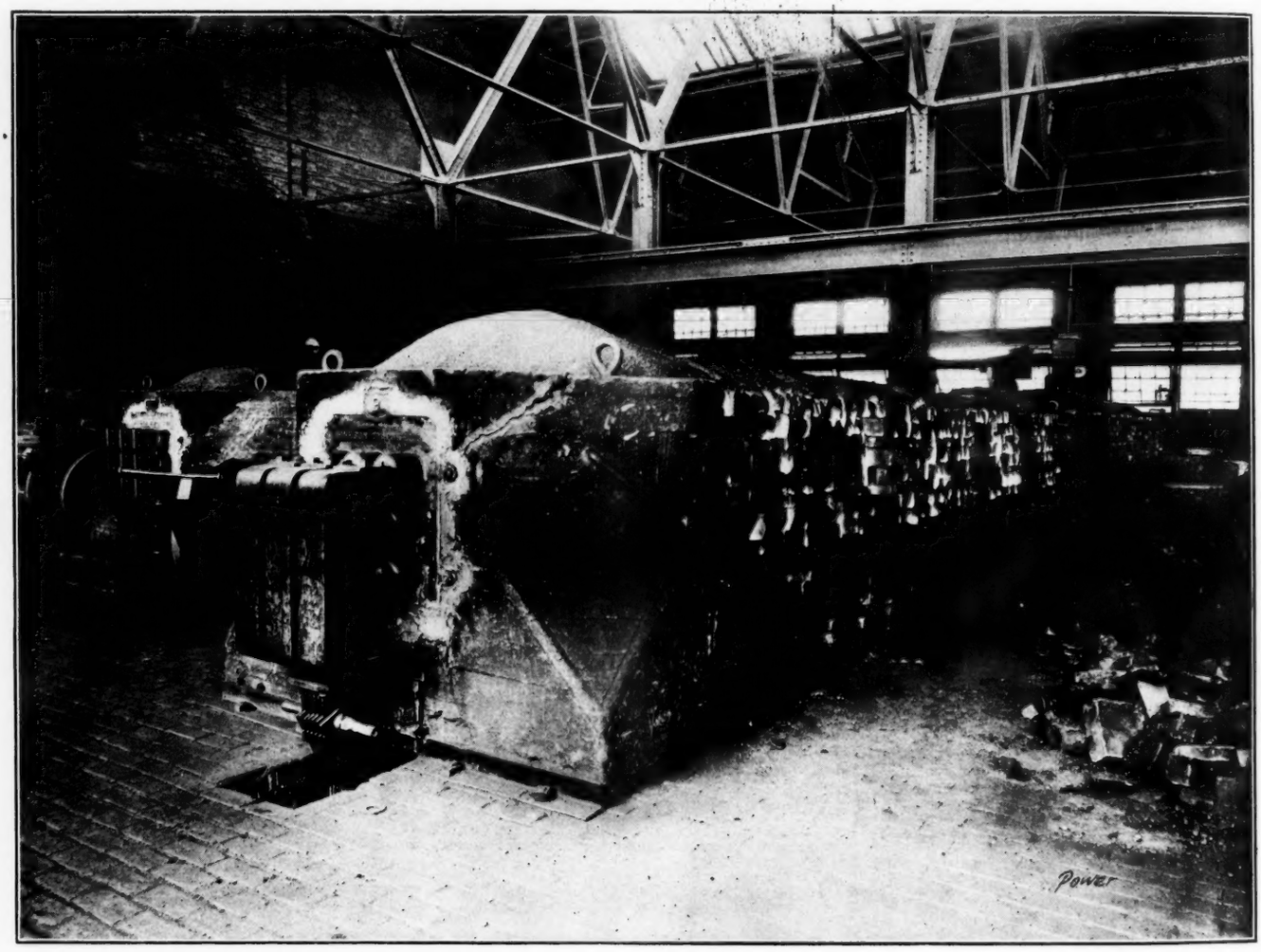


FIG. 1. ELECTRIC FURNACE IN WHICH PURE GRAPHITE IS MADE SYNTHETICALLY

gressive minds called for, and it is more than possible that in the new discoveries relative to graphite, the world is being prepared for methods which will afford greater endurance, higher efficiency and greater economy in the output of the magnificent installations of machinery man has built for doing the world's work.

In this connection it is instructive to review the synthetic production of graphite. There can be no doubt but that the rapid increase in the use of graphite and the consequent decrease in the supply of the natural product make man's ability to produce graphite of great value to the world. When the hundreds and thousands of chemical changes through which men are constantly putting the elementary bodies and the very prominent part taken by carbon in these reactions are considered, it would be astonishing if at some point in all this work man had not learned how to produce graphite superior to nature's. In the 1890 edition of Watt's "Dictionary of Chemistry," Mr. Muir mentions six recognized methods:

(1) By heating charcoal with molten iron, and dissolving out the iron with hydrochloric and nitric acids.

(2) By the slow decomposition of hydrocyanic acid, and boiling the product with nitric acid.

(3) By evaporating the mother liquors obtained in making soda. These contain cyanogen compounds which are decomposed at a certain concentration of the liquid with formation of ammonia and graphite.

(4) By leading carbon monoxide over ferric oxide at 300 to 400 degrees Fahrenheit.

(5) By the decomposition of carbon disulphide at high temperature, in contact with metallic iron.

(6) By leading carbon tetrachloride over molten pig iron.

It is doubtful if any of these methods could be developed to a commercial success. It was stated years ago that Cowles Brothers, of Cleveland, O., made report that sometimes they found that graphite occurred in or about the charge of an electric furnace they used. In 1872, F. Rose discovered a method of making graphite by exposing a cut diamond "bedded in charcoal" to a temperature equal to molten cast iron, whereby the surface is said to have become coated with graphite. Considering the value of diamonds, and the esteem in which they are usually held, it is a safe conclusion that this method will never become popular. In the 1890 edition of the "Encyclopædia Britannica" it is stated that "by heating to the high temperature afforded by a powerful galvanic battery both the diamond and amorphous carbon are converted into graphite." However, that diamonds will change to graphite when protected from chemical influences, under the influences of high temperature, is true, and, possibly, is not more than what might be expected from other known facts, but that pure, amorphous carbon will change to graphite as a result of heating is not proved.

Practically no progress of value had been made in the commercial production of graphite until the world was enriched to a wonderful extent by extended years of scientific research on the part of Dr. Edward G. Acheson. It was he who created carborundum, and, early in the history of the manufacture of that now most popular abrasive, he discovered that when carborundum was heated to a very high temperature decomposition occurred, the contained silicon passing off as vapor and a beautiful graphite left as a pseudomorph, or, as one might say, a skeleton of the original carborundum crystal. It was this discovery that started him on a

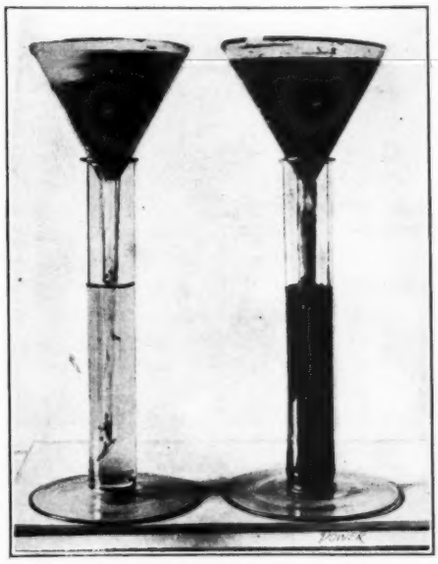


FIG. 2. FLOCCULATED AND DEFLOCCULATED GRAPHITE

new line of thought, the result of which was that after a long series of experiments the methods now employed in the making of graphite artificially were perfected.

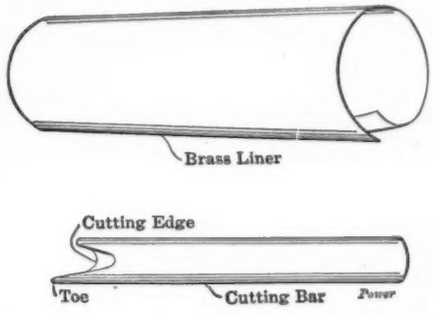
It is worthy of note in this connection that the first commercial graphitic products of the electric-furnace process, as used at Niagara, were in the form of electrodes for electrochemical work. Only recently a gentleman who occupies a very eminent position in the field of electrochemistry stated, "It may safely be asserted that electrochemistry owes its astonishing modern growth, first to the development of the dynamo and second to the production of Acheson-graphite electrodes." Under these circumstances we are led to conclude that while the production of graphite in electrode form has been so vastly beneficial to the field of electrochemistry, the production, through the operation of the same process, of practically chemically pure graphite is destined to be of equal value to the world as a lubricant.

By one process graphite artificially made is disintegrated by mechanical means, and in this form the graphite is valuable as a lubricant, or can be mixed with grease to serve as a carrier. By another process this graphite made artificially is deflocculated to such a wonderful state of fineness that it is practically molecular and will remain suspended in oil or water, the liquids serving as a carrier for the graphite. These are the things which offer recognition of the fact that as men have gone along planning and making machinery that is truly wonderful, another man, wholly unmindful of what these other men were doing, has dug out scientific secrets which go very far in making the operation of these machine installations safe through the perfect lubrication now possible through the use of synthetically produced graphite in the various forms in which it is now available.

Bar for Cutting Liners

BY GEORGE J. LITTLE

Some time ago I had occasion to remove the brass liners in a boiler-feed pump, and they were too tight to be removed without splitting. It was evident that if a cold chisel were used to split them it would be liable to damage the pump unless handled with utmost care. Therefore, I had a cutting bar made sim-



BAR AND LINER SHOWING EDGE TURNED UP BY TOE OF BAR

ilar to that shown in the sketch. The toe at the end of the bar lifts the brass and directs it against the cutting edge. When this bar is made in the right way it causes the liner to curl so that it may be removed by hand.

They hed a nigger paintin' th' 60-foot smokestack et th' power house a spell ago an' th' cuss fell off'n th' top uv it, landin' on his hed on th' cement pavement. Th' jedge fined 'im $10 fer destroyin' city property, an' th' company docked 'im 15 cents fer th' time he lost gettin' back up th' stack. Th' coon says th' only thing he feels sore 'bout is thet he didn't land on his feet 'stid uv his hed so's he cud hev brot suit fer damages agin th' company fer personal injuries he shore would haf got.

Compressed Air Transmission Tables*

By Frank Richards.

A set of tables, based upon the generally accepted formula for the flow of compressed air through pipes, and showing the loss in head for different initial pressures and rates of flow with various lengths and diameters of pipe.

The accompanying tables of pressure losses during the flow of compressed air through pipes were computed by what may be termed the Rix-Johnson formulas. J. E. Johnson, Jr., gave Churĉh's familiar formula in a simplified form in the *American Machinist,* July 27, 1899, which was, in substance, as follows:

$$R = \frac{K V^2 L}{D^5}$$

where

V = Volume of free air in cubic feet per minute;
L = Length of pipe in feet;
D = Diameter of pipe in inches;
K = A numerical constant, which Johnson fixed as 0.0006;
R = Difference between the squares of the initial and terminal absolute pressures in pounds per square inch; that is, $p^2_1 - p^2_2$.

I have reason to believe that this formula is now used in this country more generally than any other in practical compressed-air work.

E. A. Rix, of San Francisco, uses Johnson's formula with 0.0005 for the value of K. In my own practice I have found it more convenient to use the reciprocal of this value of K, that is, 2000, and transfer it to the divisor, where in actual numerical operations it almost invariably disappears at once by cancelation. I also find it more convenient to use small letters instead of capitals; hence my working formula takes the form,

$$p_1^2 - p_2^2 = \frac{v^2 l}{2000\, d^5}$$

This, of course, may be transformed to suit the special requirements, as:

$$l = \frac{2000\, d^5\, (p_1^2 - p_2^2)}{v^2}$$

$$v = \sqrt{\frac{2000\, d^5\, (p_1^2 - p_2^2)}{l}}$$

$$d^5 = \frac{v^2 l}{2000\, (p_1^2 - p_2^2)}$$

Computations in this line do not invite, nor hardly permit, micrometrical precision, and refinements are out of place; hence it is quite permissible and very convenient to use 15 pounds for the normal atmospheric pressure, and this has been done in computing the tables herein given. A single example of the process will suffice.

Let there be 5000 feet of 8-inch pipe, through which it is desired to transmit 4000 cubic feet of free air per minute at an initial pressure of 105 pounds gage, or 120 pounds absolute. What will be the terminal pressure and the loss of head? The pressure here assumed is not unusual in the best practice of the present day.

Note that d^5 (8^5) is 32,768, and p_1^2 (120^2) is 14,400. By substituting these values the formula may be expressed as follows:

$$\frac{4000^2 \times 5000}{2000 \times 32{,}768} = p_1^2 - p_2^2 = 14{,}400 - p_2^2$$

Then,

$$p_2^2 = 14{,}400 - 1220 = 13{,}180$$

and

$$p_2 = 114.80 \text{ pounds}$$

absolute terminal pressure; hence the loss of pressure is,

$$120 - 114.80 = 5.20 \text{ pounds.}$$

The foregoing example shows what may be considered a suitable rate of pipe transmission, or a flow which should not be much exceeded in practice. The free air in this case being 4000 cubic feet per minute, and the initial absolute pressure being 8 atmospheres, the actual volume, assuming that aftercoolers are used and that the air is at normal temperature, will be only 500 cubic feet per minute. The volume content of an 8-inch pipe is 0.349 cubic feet per foot of length; therefore the rate of flow will be

$$500 \div 0.349 = 1432 \text{ feet}$$

per minute. A handy limit figure to keep in mind is the round number 1500 feet per minute.

The loss of pressure will be a little more than proportional to the squares of the volumes of free air. That is, if in this case the volume of free air had been

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LOSS OF HEAD IN TRANSMISSION THROUGH PIPES.

1-INCH PIPE.

Initial Pressure, 75 Pounds, Gage.						Initial Pressure, 90 Pounds, Gage.						Initial Pressure, 105 Pounds, Gage.					
Free Air per Minute, Cubic Feet.	Flow in Pipe per Minute, Feet.	Length of Pipe in Feet				Free Air per Minute, Cubic Feet.	Flow in Pipe per Minute, Feet.	Length of Pipe in Feet.				Free Air per Minute, Cubic Feet.	Flow in Pipe per Minute, Feet.	Length of Pipe in Feet.			
		100	200	300	400			100	200	300	400			100	200	300	400
12.5	385	0.05	0.09	0.13	0.17	12.5	330	0.04	0.08	0.11	0.15	12.5	289	0.03	0.06	0.10	0.13
25	771	0.18	0.35	0.53	0.70	25	661	0.15	0.30	0.45	0.59	25	578	0.12	0.25	0.40	0.52
50	1543	0.69	1.40	2.11	2.83	50	1322	0.59	1.19	1.81	2.41	50	1157	0.52	1.05	1.56	2.10
75	2314	1.58	3.18	4.82	6.49	75	1984	1.35	2.72	4.10	5.51	75	1736	1.10	2.25	3.40	4.68
100	3086	2.82	5.74	8.76	11.89	100	2645	2.41	4.88	7.41	10.00	100	2313	2.11	4.25	6.42	8.65

1½-INCH PIPE.

		Length of Pipe in Feet.						Length of Pipe in Feet.						Length of Pipe in Feet.			
		250	500	750	1000			250	500	750	1000			250	500	750	1000
25	339	0.06	0.12	0.18	0.23	25	291	0.05	0.10	0.15	0.20	25	254	0.04	0.08	0.12	0.17
50	679	0.23	0.46	0.69	0.92	50	582	0.19	0.39	0.59	0.79	50	510	0.17	0.33	0.50	0.68
100	1358	0.92	1.85	2.79	3.74	100	1164	0.79	1.58	2.38	3.18	100	1019	0.69	1.38	2.07	2.76
150	2037	2.08	4.22	6.39	8.64	150	1746	1.78	3.59	5.43	7.30	150	1528	1.53	3.14	4.65	6.32
200	2716	3.74	7.64	11.73	16.06	200	2328	3.18	6.47	9.87	13.39	200	2037	2.76	5.55	8.51	11.54

2-INCH PIPE.

		Length of Pipe in Feet.						Length of Pipe in Feet.						Length of Pipe in Feet.			
		200	500	1000	2000			200	500	1000	2000			200	500	1000	2000
100	764	0.17	0.43	0.87	1.75	100	655	0.15	0.37	0.75	1.50	100	573	0.13	0.32	0.65	1.30
150	1146	0.39	0.98	1.97	3.99	150	982	0.34	0.83	1.69	3.40	150	859	0.29	0.74	1.47	2.95
200	1528	0.69	1.75	3.54	7.24	200	1310	0.59	1.51	3.02	6.48	200	1146	0.53	1.32	2.64	5.28
250	1910	1.09	2.31	5.60	11.60	250	1637	0.93	1.97	4.76	9.75	250	1433	0.83	2.09	4.17	8.35
300	2292	1.57	4.92	8.18	17.28	300	1965	1.35	3.45	6.92	14.37	300	1719	1.22	3.06	6.13	12.25

LOSS OF HEAD IN TRANSMISSION THROUGH PIPES.

2½-INCH PIPE.

		Length of Pipe in Feet.						Length of Pipe in Feet.						Length of Pipe in Feet.			
		1000	1500	2000	2500			1000	1500	2000	2500			1000	1500	2000	2500
100	489	0.29	0.44	0.59	0.73	100	419	0.25	0.38	0.51	0.62	100	367	0.22	0.32	0.43	0.55
200	978	1.16	1.74	2.32	2.89	200	838	0.98	1.47	1.96	2.47	200	734	0.86	1.29	1.73	2.15
300	1467	2.6	3.91	5.25	6.64	300	1257	2.22	3.34	4.45	5.64	300	1100	1.94	2.88	3.87	4.95
400	1956	4.64	6.96	9.30	12.20	400	1676	3.98	6.00	8.00	10.25	400	1467	3.45	5.18	7.00	8.86
500	2450	7.50	10.00	15.10	18.90	500	2100	6.25	9.38	12.56	15.72	500	1838	5.45	8.20	11.15	14.17

3-INCH PIPE.

		Length of Pipe in Feet.						Length of Pipe in Feet.						Length of Pipe in Feet.			
		1000	1500	2000	2500			1000	1500	2000	2500			1000	1500	2000	2500
100	339	0.12	0.17	0.23	0.29	100	291	0.10	0.15	0.20	0.25	100	254	0.09	0.13	0.17	0.22
200	679	0.46	0.69	0.92	1.15	200	582	0.39	0.59	0.79	0.99	200	509	0.35	0.53	0.69	0.87
400	1358	1.86	2.79	3.75	4.69	400	1164	1.58	2.39	3.19	3.99	400	1019	1.41	2.12	2.76	3.48
600	2037	4.21	6.39	8.65	10.81	600	1746	3.59	5.43	7.31	9.14	600	1528	3.13	4.83	6.48	8.16
800	2716	7.64	11.74	16.11	20.15	800	2328	6.47	9.87	13.43	16.79	800	2037	5.74	8.72	11.78	14.65

4-INCH PIPE.

		Length of Pipe in Feet.						Length of Pipe in Feet.						Length of Pipe in Feet.			
		1000	1500	2000	2500			1000	1500	2000	2500			1000	1500	2000	2500
250	477	0.17	0.26	0.34	0.43	250	409	0.15	0.24	0.29	0.37	250	358	0.12	0.19	0.26	0.32
500	955	0.68	1.02	1.37	1.71	500	818	0.58	0.82	1.17	1.47	500	716	0.51	0.76	1.02	1.28
750	1432	1.54	2.32	3.10	3.89	750	1227	1.31	1.98	2.65	3.32	750	1074	1.15	1.73	2.31	2.89
1000	1910	2.76	4.17	5.60	7.06	1000	1637	2.35	3.55	4.76	5.98	1000	1433	2.05	3.09	4.14	5.20
1250	2387	4.34	6.52	8.91	11.29	1250	2046	3.49	5.59	7.53	9.51	1250	1790	3.22	4.86	6.53	8.22

6-INCH PIPE.

		Length of Pipe in Feet.						Length of Pipe in Feet.						Length of Pipe in Feet.			
		1000	2500	5000	10,000			1000	2500	5000	10,000			1000	2500	5000	10,000
1000	849	0.36	0.89	1.81	3.65	1000	727	0.31	0.77	1.54	3.10	1000	637	0.27	0.67	1.34	2.70
1500	1273	0.81	2.04	4.12	8.46	1500	1091	0.63	1.74	3.51	7.15	1500	955	0.61	1.51	3.04	6.16
2000	1698	1.44	3.64	7.45	15.64	2000	1454	1.23	3.10	6.31	13.05	2000	1274	1.08	2.70	5.46	11.19
2500	2122	2.26	5.75	11.93	26.14	2500	1817	1.93	4.89	10.07	21.25	2500	1591	1.69	4.27	8.69	18.12
3000	2547	3.28	8.45	17.86		3000	2181	2.79	7.14	14.84		3000	1910	2.43	6.16	14.55	27.05

8-INCH PIPE.

		Length of Pipe in Feet.						Length of Pipe in Feet.						Length of Pipe in Feet.			
		1000	2500	5000	10,000			1000	2500	5000	10,000			1000	2500	5000	10,000
2000	954	0.34	0.85	1.71	3.46	2000	818	0.29	0.73	1.47	2.95	2000	716	0.26	0.64	1.28	2.57
3000	1432	0.77	1.92	3.89	7.97	3000	1227	0.66	1.64	3.32	6.75	3000	1074	0.57	1.44	2.90	5.87
4000	1909	1.37	3.46	7.06	14.77	4000	1636	1.17	2.95	5.98	12.35	4000	1432	1.02	2.57	5.20	10.65
5000	2386	2.15	5.46	11.29	24.51	5000	2045	1.83	4.64	9.51	20.06	5000	1790	1.60	4.04	8.23	17.61
6000	2864	3.10	7.98	16.83		6000	2454	2.65	6.75	14.00		6000	2148	2.31	5.86	12.05	26.16

10-INCH PIPE.

		Length of Pipe in Feet.						Length of Pipe in Feet.						Length of Pipe in Feet.			
		2500	5000	7500	10,000			2500	5000	7500	10,000			2500	5000	7500	10,000
1000	313	0.06	0.14	0.21	0.28	1000	268	0.05	0.12	0.18	0.24	1000	235	0.05	0.11	0.16	0.21
2000	627	0.27	0.56	0.84	1.12	2000	537	0.24	0.48	0.72	0.95	2000	470	0.21	0.42	0.63	0.84
4000	1254	1.11	2.25	3.37	4.56	4000	1075	0.95	1.92	2.88	3.88	4000	941	0.84	1.68	2.53	3.38
6000	1881	2.52	5.15	7.73	10.62	6000	1612	2.16	4.38	6.57	8.95	6000	1411	1.89	3.81	5.76	7.75
8000	2508	4.54	9.37	14.06	20.06	8000	2150	3.86	7.82	11.73	16.54	8000	1881	3.38	6.87	10.46	14.17

12-INCH PIPE.

		Length of Pipe in Feet.						Length of Pipe in Feet.						Length of Pipe in Feet.			
		2500	5000	7500	10,000			2500	5000	7500	10,000			2500	5000	7500	10,000
2,500	530	0.17	0.35	0.52	0.68	2,500	455	0.15	0.30	0.45	0.59	2,500	398	0.13	0.27	0.39	0.53
5,000	1061	0.70	1.41	2.11	2.84	5,000	910	0.62	1.21	1.81	2.42	5,000	796	0.53	1.05	1.58	2.11
7,500	1591	1.59	3.15	4.73	6.45	7,500	1365	1.35	2.69	4.03	5.53	7,500	1193	1.18	2.37	3.59	4.81
10,000	2122	2.83	5.77	8.66	11.95	10,000	1820	2.40	4.89	7.34	10.05	10,000	1591	2.11	4.27	6.46	8.69
12,500	2652	4.45	9.19	13.79	19.59	12,500	2275	3.79	7.76	11.64	16.19	12,500	1989	3.32	6.73	10.25	13.88

doubled, making 8000 cubic feet instead of 4000 cubic feet, the loss of head would have been 22.44 pounds instead of 5.20 pounds.

It is worth while to note how the pressure loss is diminished as the pressure is increased, due to the reduction of volume. Thus, in 1000 feet of 1-inch pipe, transmitting 50 cubic feet of free air per minute, the pressure losses for diminishing initial pressures would be as follows:

Initial Pressures.	Loss of Press.
45 pounds gage	11.52 pounds.
60 pounds gage	8.86 pounds.
75 pounds gage	7.24 pounds.
90 pounds gage	6.14 pounds.
105 pounds gage	5.33 pounds.
120 pounds gage	4.71 pounds.
135 pounds gage	4.23 pounds.
150 pounds gage	3.83 pounds.

Of course, no tables can be compiled which will cover the various requirements of compressed-air practice, but the figures herein given may at least furnish a working idea of the probabilities, and may be of service in a general way in preliminary estimates, or may serve to detect errors or inconsistencies which are apt to occur in the most careful figuring. No precise agreement with actual practice can be expected, as conditions which affect the result are so numerous.

Factors Affecting Plant Costs

By H. J. Macintire

A few suggestions as to the factors which determine the location of a steam plant and the selection of its equipment. A graphical method is shown whereby the most economical cutoff for a given engine may be determined.

In new construction the fact is often overlooked that local conditions govern the choice of the equipment. Therefore, in choosing the equipment for a plant, it is well to consider the following items:

First Cost of the Plant—This includes the cost of engines, generators and auxiliaries, the building itself, chimneys, the construction for the storing and handling of coal and ash removal, and the cost of land, right of way, etc.

Depreciation—This includes not only the allowance for wear and tear but also takes into account the fact of the machinery becoming obsolete. The latter has an important bearing in certain types, and the question of obsoleteness may make it necessary to replace immediately the old machinery with that of new design. Although it is proper to charge only 4 per cent. for the yearly depreciation on the entire plant (this varies from 3 per cent. for the building to 7½ per cent. for the generators and 10 per cent. for the boilers), yet the allowance for the uncertain factor of obsoleteness will make the total rate about 8 per cent.

Cost of Maintenance and Supplies—This includes packing, waste, oil and repairs, the latter differing with different types of engines.

Fuel—This is often the factor of greatest weight. In the coal regions it is of less importance, but in those districts which require a long railroad haulage of fuel it becomes of considerable importance. In fact, the cost of the fuel determines the kind of engine that is practical, for a more expensive engine which can be run with economy is the better one to use where the cost of fuel is high, than a cheaper one using more steam. The three following factors govern the choice of design:

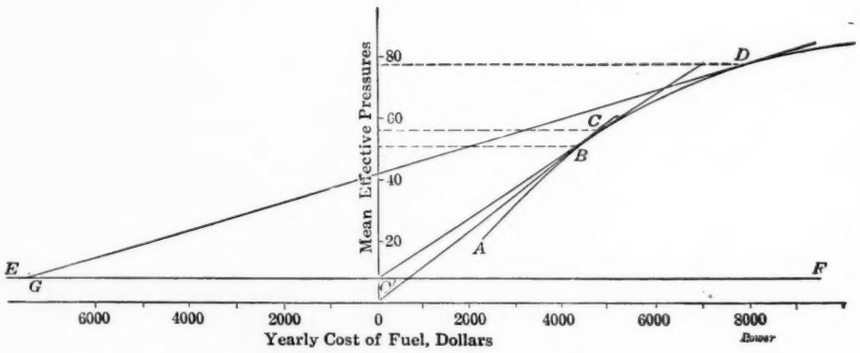
The cost of fuel per ton.

The number of hours of operation per year.

The load factor.

If power is used only a few hours a day the fuel cost can be practically disregarded and attention directed toward keeping the first cost as low as possible. A simple engine may give good economy at full load, but very poor at light loads. Therefore the load factor plays an important part in the selection of the engine.

Degree of Duplication of the Plant—In public utilities it is absolutely necessary that no shutdown occur, whereas in a mill or factory a shutdown, while undesirable, is not so important. Where everything is in duplicate there is a tendency toward employing cheaper engines, because of the smaller first cost. Also, it is often possible to use somewhat obsolete machines for emergencies, and have the uptodate and economical ones for the everyday work; this, however, is not so applicable to entirely new plants.



GRAPHICAL REPRESENTATION OF COSTS

Utilization of Exhaust Steam—In steam heating, or in the absorption system of refrigeration where all the exhaust is used, nearly all the heat of the steam can be utilized; but in the condensing type it is possible, at best, to obtain an efficiency of only 15 to 20 per cent. In the first case a high-speed noncondensing engine, using 40 pounds of steam per horsepower-hour, can be employed; here the first cost is small and yet the economy is great. But in the case of the condensing engine the economy must be in the engine itself, for most of the heat carried to the condenser is lost.

Cost of Condensing Water—If the plant is on a river, lake or other body of water this is unimportant, but when not so located and especially when the plant is in a city or on the plains of the West, the cost of the condensing water becomes a governing factor. If a cooling tower is used, the interest on the investment and the cost of power for the fan are considerable.

Minor Factors—These include the location where absolute safety of the plant is important, as in office buildings, etc.

It is now a common custom to build double-decked power stations, putting the turbine directly over the boilers, thereby saving in piping and in floor space. This is possible with turbines because of the uniform turning moment and perfect balance of the moving parts. With such an arrangement a barometric tube condenser can be easily and cheaply employed.

To summarize, it may be said that where fuel is cheap, an inexpensive and uneconomical form of boiler and engine may be used, and where land is expensive it may be necessary to use water-tube boilers and turbines arranged on the double-deck plan, or to use high-speed engines. In pumping plants, or where power is used 24 hours a day and 365 days a year, the fuel is the most expensive item and an economical and necessarily expensive form of engine and boiler should be chosen.

Sometimes it is a question as to the most desirable method of operation. Professor Jacobus found in a certain engine test (American Society of Mechanical Engineers, Volume 24) that one-half load was the most economical, and that there was a saving of 5 per cent. of the coal (12.1 pounds of steam as against 12.76 pounds per indicated horsepower per hour) in operating at one-half load. The plant used 2000 tons of coal per year, which at $4 per ton amounted to $8000. A 5 per cent. saving of this sum amounted to $400 a year.

The cost of doubling the size of the engine to be able to run at one-half load would have been $22,000 and 5 per cent. interest on this additional first cost would have been $1100. Hence,

$$\$1100 - \$400 = \$700$$

loss due to the installation of the larger engine so as to run at the more economical load. Of course there is the item of the increase of power should it ever be desired, but the question of depreciation and obsoleteness would then have to be considered. It would be unwise in most cases to install much more than the required size of engine unless there is a reasonable possibility of more power being required later on.

There is a graphical method of representing the costs under various load

factors which is very interesting. It has been shown that the steam consumption is not the only important item, but, on the other hand, the only thing that varies directly with the load is the fuel (except minor items, such as waste, lubricating materials, etc.). Suppose then that the mean effective pressure is plotted against the cost of fuel per year, the result will be a curve *A B C D* as shown. The tangent *O' B* will give a point in the curve where the most economical mean effective pressure for this particular condition lies, as the ratio of the cost of fuel to the mean effective pressure is greatest there. Having the mean effective pressure it is easy to figure back and obtain the corresponding cutoff. If a line *E F* is drawn a distance above the lower line such that *O O'* equals the mean effective pressure corresponding to the friction horsepower, then *O' C* will give a point on the curve for the most economical brake horsepower.

So far only the cost of the fuel has been considered. Therefore, represent by *O' G* the cost of all the other items, such as interest on the first cost of the plant, depreciation, taxes, maintenance, water, oil, waste, wages, etc. Then the tangent drawn to the curve from *G* will give a point *D* as the most economical cutoff under the actual conditions.

Operating Notes on Refrigeration

By F. E. Matthews

The discussion is limited to the defrosting of brine and direct-expansion coils, removal of oil and permanent gases from the system and the effect of incrustation on the condenser coils.

Defrosting Refrigerating Coils

The problem of defrosting cold storage coils is one which is too often ignored at the time of making the installation. Where such has been the case the operator often finds himself working at great disadvantage, not only because of his inability to produce the required temperature, but also because of the decreased efficiency of the mechanical equipment entailed by the reduction in back pressures necessary to coax the heat from the cold-storage rooms through the additional resistance offered to its passage by the accumulated ice. This disadvantage affects principally the coal bill and fortunately for the operator, though unfortunately for the owner, is in the majority of cases not recognized, or, if apprehended, is not charged to the proper account.

The effect of a coating of ice on direct-expansion pipes may be shown as follows: Assuming a heat transfer of 10 B.t.u., in round numbers, per hour, per square foot per degree of difference in temperature inside and out, for a flat metallic refrigerating surface,* and an equal amount for a sheet of ice 1 inch thick, it follows that the heat transmission through a square foot of direct-expansion cooling surface insulated with a layer of ice 1 inch thick will be only one-half that of the uncoated surface. As a matter of fact, it would seem from the context that the value of 10 B.t.u. given as the heat conductivity of ice, applied to plate-ice conditions under which the wetted surface of the submerged ice will transmit materially more heat than a dry surface in contact with air. This would indicate that the decrease in heat-transmitting capacity of direct-expansion surfaces in air due to a coating of ice is even more than 50 per cent. This condition will be partially offset by the fact that on account of the increasing diameter, the layer of ice in the case of cylindrical surfaces such as pipes, which, together with the fact that such coatings usually present an irregular surface, further increasing the heat-absorbing area, may increase the heat transmission sufficiently to make up for the lesser heat transfer between the air and dry ice and make 50 per cent. at least a reasonable estimate of the loss in heat-absorbing capacity due to 1 inch of ice.*

Brine pipes may be readily defrosted by the circulation of hot brine. This may be accomplished through the main feed and return headers where the operation does not have to be performed very frequently, or as in abattoirs where the excessive amounts of moisture from the hot meats to be chilled make the accumulation of frost very rapid, or by a separate set of defrosting headers.

In the case of direct-expansion coils, the defrosting method probably most satisfactory where the cold-storage temperatures are above 32 degrees Fahrenheit is to install sufficient coil surface to allow a part of the coils to be shut off at any time, so that the frost will melt without artificial heat and at the same time produce a certain amount of useful refrigeration. If it is necessary to force the defrosting process by the use of outside heat, a hot gas line from the condenser may be connected to the liquid-line connections to the separate coils just inside the expansion valves. The hot gas, after melting the ice as it passes through the coils, returns to the compressor together with the return gas from the remaining coils.

Where the temperatures carried in the cold-storage compartments are below 32 degrees Fahrenheit, and in which the defrosting cannot be effected without the use of artificial heat, often very objectionable, two methods are available, viz.: that of forcibly removing the ice with scrapers, and that of suspending over the pipes trays of calcium chloride. This substance is exceedingly deliquescent salt, which in absorbing moisture from the air forms a saturated calcium brine which freezes at a very low temperature. In trickling down over the coils, the brine melts the ice, forming a more dilute brine which is then conducted away to the sewer, or, if the quantities involved warrant the expenditure of labor, may be evaporated and the calcium chloride recovered.

Oil in the Refrigerating System

Next to unintelligent design which sometimes provides for the operating engineer a plant that cannot be made to develop nearly as high efficiency as operating conditions would warrant, and unintelligent operation which fails to get nearly as high efficiency as operating conditions and mechanical design would warrant, the worst foe to economy is foreign matter in the refrigerating system.

In order that the oils used in the system shall not stiffen prohibitively at the low temperatures encountered and not be saponified by the ammonia, only very light mineral oils can be employed. Such oils range from 22 to 30 degrees Baumé, corresponding to a specific gravity of from 0.924 to 0.88. These oils should have a cold test of about zero Fahrenheit, to obtain which they will have a flash point of between 310 and 400 degrees Fahrenheit. This low flash point implies that a considerable amount of vapor will be given off at a much lower temperature. Since discharge temperatures of compression machines often approach these temperatures, it is obvious that a considerable amount of oil will pass to the condenser, not as a liquid but as a vapor. Under such conditions, since there is no material cooling effect in the oil separator, only liquid oil would be precipitated at that point.

Baffle plates on which the discharged gas impinges and to which particles of oil will tend to stick by adhesion as well as on account of the abrupt reversal of direction of flow of the gas which tends

*See Siebel's "Compend of Mechanical Refrigeration and Engineering," pages 190 and 207.

*Under average commercial conditions of intermittent frosting a square foot of direct-expansion surface in air is usually credited with a heat transmission of only from 2 to 4 B.t.u. per hour per degree difference in temperature.

to separate out the slightly denser substances by centrifugal force, are precautions in the right direction; but except when discharge temperatures are low it is useless to expect to intercept all of the oil until it has been actually condensed. This operation being carried out most effectively in the condenser, the oil will pass to the receiver with the liquid ammonia, where, since there is a difference in specific gravity of 0.23 to 0.27, the separation can be more easily effected.

The question of removing oil from the expansion coils, whether they are used for chilling cold-storage rooms, for chilling brine to be circulated through cold-storage rooms or for chilling the brine of an ice tank, is one which has received much attention, but, although much experimenting has been done and a few patents have been issued, no cheap and effective method has yet been devised where coils will drain so that there will be no danger of entrapping condensed moisture. The most effective method of removing the oil is to pump out the coils, disconnect them and blow them out with the highest-pressure live steam available, letting the steam blow through each coil as long as any oil appears at the exhaust end. The brine may be left in the tank and heated up by steam, so as to prevent, as far as possible, the condensation of steam inside the pipes, or if the brine has been removed the same result may be obtained by leaving the covers on the tank and blowing in live steam.

After the steam has been blown through the coils until no more oil appears, each coil should again be blown out with air to remove any traces of moisture from the steam. The moisture-absorbing capacity of the air can also be increased by heating it before it is introduced into the coils. The coils themselves may be heated as previously described. Long coils cannot be perfectly cleaned cold by air alone. Where coils will not drain in the tank as installed, the only effective way of extracting the oil is to remove the brine and disconnect them at such points as will enable them to drain, or remove them from the tank entirely. In case this method cannot be employed, ammonia purifiers may be installed with advantageous results. These purifiers work continuously when the plant is in operation, and their action can be facilitated by frequently pumping out the system. While it can hardly be expected that all of the oil can ever be removed by this means, their slow but continuous action is of great benefit in plants in which it is impossible to shut down in order to employ more effective methods, and will largely prevent the accumulation of oil in new or recently cleaned systems.

Permanent Gases

The action of so called permanent gases in the condenser is less detrimental than that of oil in the expansion coils which forms an insulating lining of fairly high efficiency on the inside of the heat-absorbing surfaces. The principal effect of these gases, if their operation can be limited to the condensers, is to occupy space that should be available for the ammonia gas. This reduces the effective area of the condenser cooler surface, causing an increased head pressure with the usual amount of cooling water and demanding an increased amount of cooling water to maintain the same head pressure.

These so called permanent gases are of rather uncertain origin and, as the name implies, are gases not liquefiable under the same conditions of temperature and pressure as ammonia. In a new plant or one recently overhauled they may consist almost wholly of atmospheric air. In an old one they are more likely to consist of nitrogen and hydrogen from decomposed ammonia, vapors of oil and mixtures of other hydrocarbon gases formed by the action of heat on hydrogen in the presence of vapors of oil, and water and other impurities contained in ammonia.

There is a considerable difference in opinion as to whether or not these gases are heavier or lighter than ammonia, and accordingly whether they can be most readily purged from the highest or the lowest part of the system. It seems reasonable to suppose that on account of the comparatively rapid flow of the ammonia vapors through the system, that sooner or later these gases, wherever formed, will find their way to the condenser. If the liquid outlets from the condenser are properly sealed, there will be no other way for them to escape than through the purge valve at the top of the condenser. If these gases are lighter than ammonia they will accumulate at the top of the condenser, and if heavier they will be driven to the top by the re-expanding ammonia in the bottom of the condenser as soon as the pressure is removed by the opening of the purge valve.

Condensers should be purged as often as the accumulation of gases indicate that they need it. To do this most advantageously, the liquid outlet and hot-gas inlet valves of the coils to be purged should be closed and a liberal supply of cooling water allowed to flow over them for some time. The permanent gases can then be purged out through a small rubber tube one end of which is connected to the purge valve; the other end should be immersed in a pail of water. If permanent gases escape when the purge valve is slowly opened, bubbles will rise to the surface of the water. If only ammonia escapes, the bubbles of ammonia gas will be dissolved in the water before reaching the surface, giving rise to a sharp crackling sound such as that caused by the condensation of steam in the process of heating water by the direct admission of steam through an open pipe.

When the water in the pail has become saturated and accordingly cannot absorb more ammonia, the bubbles will rise to the surface and it is difficult to discriminate between ammonia and the other gases. For this reason it is advisable to replace the aqua ammonia formed by fresh water, often enough so that it will not become saturated.

Incrustation on Condenser Coils

While the comparatively high working temperature of condenser coils, together with the usually ample provisions for draining each separate coil, prevents the accumulation of such large quantities of oil as are often lodged in expansion coils, condenser coils are exposed to another source of loss of efficiency from without, where the available cooling water is abnormally hard or carries a large amount of suspended matter. Ammonia condensers, and especially steam condensers, soon become coated with a deposit of scale or mud, which, if not properly removed, becomes a more or less effective insulator according to the composition of the deposit. The heat conductivity of metallic surfaces is not the same per degree difference in temperature at medium and low as it is for high temperatures, and it does not therefore follow that the resistance offered by the scale accumulating on the outside of atmospheric and submerged ammonia and steam condensers is the same as that of scale on the inside of a boiler. However, some slight idea of the extent of the loss may be gained from the fact that in steam-boiler practice, the insulating effect of scale results in a thermal loss corresponding to 2 per cent. of the fuel for each 1/64 inch in thickness of scale. Condenser surfaces like those of steam boilers, expansion coils or any other heat-transmitting surfaces should be kept as free as possible from deposits of foreign matter.

It seems superfluous to state that the heat-absorbing surfaces of brine-cooling coils and the heat-radiating surfaces of condenser coils should always be kept covered with brine and condenser water respectively. Nevertheless, it is not uncommon to see refrigerating plants operating with the brine so low in the tanks that the top expansion coils are exposed and the distribution of water over the condensers so irregular that a large percentage of the surface is dry.

Bill Grimes hez bin havin' a lot uv trubble keepin' th' packin' in th' cylinder hed uv his pump. It kept blowin' out so dumd fast thet he didn't hev any more left so he went over t' th' 'rest-yer-aunt an borrered a pancake uv th' cook an' packed it with thet. He sez th' gol darnd pump ain't leaked a drap since.

Soot Blowers and Soot Suckers

By Warren O. Rogers

The steam soot cleaner has entered largely into the work of cleaning boiler tubes, because it is easy to operate and gives satisfactory results. Thirty-nine different designs are given attention.

The simplest form of steam tube blower consists of an ordinary piece of ¾- or 1-inch steam pipe attached to a hose. While such a device will partly clean a tube, the current of steam will draw an excessive amount of air into the tube being blown, and when moving the pipe from one tube to another, soot is liable to be blown about the boiler room and surroundings, as pictured in Fig. 1.

An early type of tube cleaner is shown in Fig. 2; it was a combination tube blower and scraper. Steam was used to blow the soot and scale back through the tubes into the combustion chamber. The scraping portion was confined to the head and consisted of from five to seven annular rings having sharp edges cast upon its outer surface. These rings were made of such diameter as to easily pass into and through the tube, the sharp edges acting as scrapers upon the inside surface. The head was attached to a piece of pipe which was connected to the steam supply by means of a rubber hose.

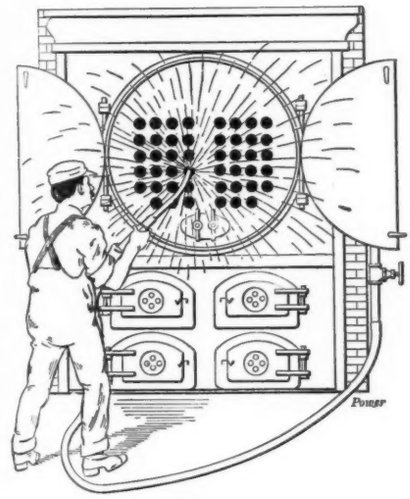


FIG. 1.

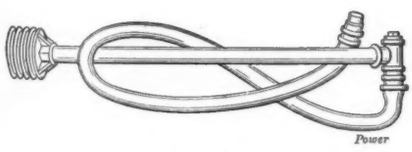


FIG. 2.

What is termed an automatic cleaner is shown in Fig. 3. Steam is admitted to the head through a valve which is controlled by a rod and thumb grip. The valve remains closed except when the head is placed at a tube end. When ready to blow, the operator's thumb is pressed on the grip and the steam blows the soot out of the tube. This arrangement saves steam and prevents soot from being blown out into the boiler room when passing the blower from one tube to another. It is made by the Jarecki Manufacturing Company.

Another design of blower, made by James A. Griffiths, is shown in Fig. 4. The head is beveled on the outside so as to fit snugly to the tube end. Steam enters the head through a tee, pipe and rubber hose. A spade handle makes it an easy matter to manipulate the cleaner. The steam pipe is fitted with a valve. By placing the head at the tube end and opening the valve, steam and air are blown into the tube. A sectional view of the head is also shown, the outer passage being for air.

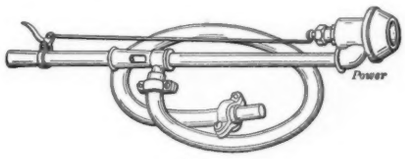


FIG. 3.

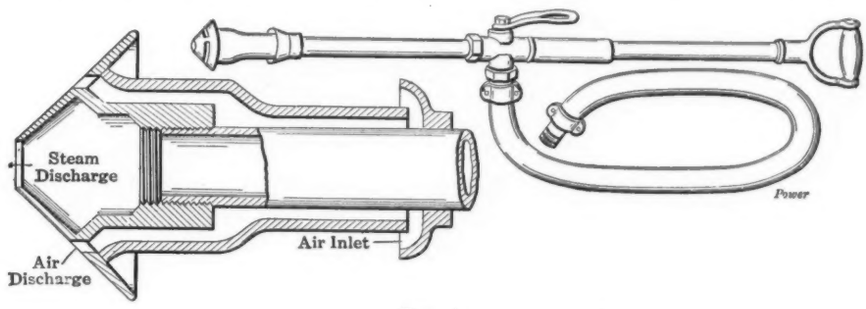


FIG. 4.

A device known as the McLaughlin cleaner and shown in Fig. 5 was made so that the outlet could be adjusted to regulate the supply of steam to any desired velocity by screwing the cap piece toward or away from the mouth of the orifice. As the opening was reduced the velocity of the steam increased, so that the blast would be effective at the far end of the tube. What was known as the "Perfection" steam cleaner is illustrated in Fig. 6. Its design permitted of shutting off the steam, while passing the head from tube to tube, by means of the steam cock placed between the handle and the hose. It was so arranged that it could be operated by the left hand while the cleaner was handled with the right.

The nozzle was made in the form of a truncated cone and fitted tightly to the tube end, thereby preventing the introduction of air and forcing dry steam the entire length of the tube.

Fig. 7 illustrates a steam tube cleaner manufactured by the Darling Pump and Manufacturing Company. The device consists of a hollow head with openings provided as shown at *A*. These outlets are so shaped as to give a swirling motion to the steam.

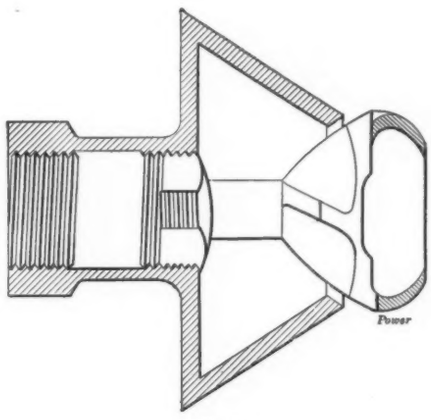


FIG. 5

What was called the "King Bee" cleaner is shown in Fig. 8. In operation, air and steam were admitted to the tubes being cleaned. The steam entered through the openings in the center of the head, the air entering around the spiral ribs on the outside of the head.

Fig. 9 shows another type of tube blower made by A. W. Chisholm & Co. The steam can be turned on full force without being wasted. The head, when pressed against the tube, is forced back, thus opening a valve which allows steam to pass through the hose only when the head is in position to blow a tube. The steam leaves the head through curved outlets which extend to its mouth, the aim being to blow the steam spirally through the entire length of the tube.

A "Cyclone" steam tube cleaner is shown in Fig. 10. The steam enters the

cleaner head through the hose connection and is given a twisting motion as it passes through the head, the outlet being through the slot shown. It is made by the Crescent Manufacturing Company.

An injector blower, shown in Fig. 11, is made by John S. Bushnell & Co. A small amount of steam draws in a

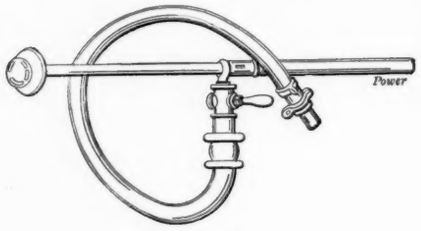


FIG. 6.

FIG. 7.

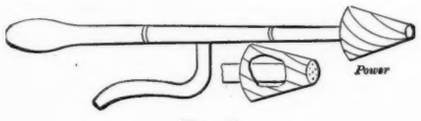


FIG. 8.

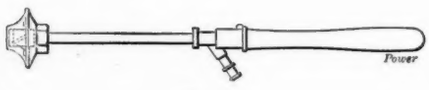


FIG. 9.

FIG. 10.

current of air which is heated and driven through the tubes. The steam is admitted to the center of the head through the small openings. The air mingling with the steam is forced through the tubes at high velocity.

The cleaner shown in Fig. 12 was invented by William Coggeshall. The moisture in the steam is absorbed by the introduction of a current of air which is heated by the steam. This blast of hot air and steam expels the soot, ashes and rough scale. The steam is expelled through the center of the head and the air is admitted into the tube between the ribs on the head.

Another design of tube blower is illustrated in Fig. 13. It consists of a head having three steam outlets, each outlet being separated by a cone-shaped center piece. In operation the cleaner is used in the same way as most other devices of like type.

A whirlwind type of tube cleaner is made by the A. W. Chesterton Company. The internal construction of the head of this cleaner is shown in the sectional view of Fig. 14. The passage of the steam through the head keeps an inner revolving head in continuous rotation, which imparts a rotary motion to the steam and air in passing through the tubes.

The "Correct" steam flue cleaner, shown in Fig. 15, is automatic in its working, as it permits a passage of steam through the head only when in use. After opening the steam valve in the supply steam pipe, the full force of the steam pressure is on the head of the cleaner

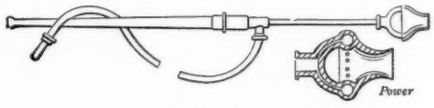


FIG. 11.

FIG. 12.

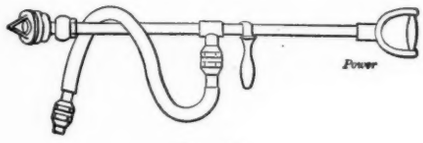


FIG. 13.

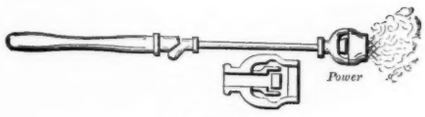


FIG. 14.

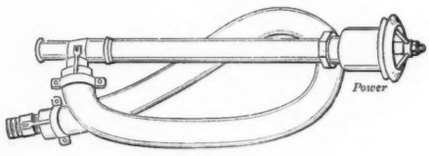


FIG. 15.

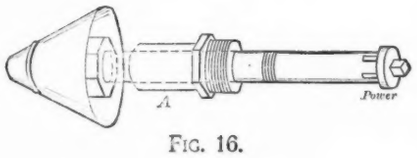


FIG. 16.

and within 2 inches of the end of the flue when in position to use.

A slight pressure on the handle will force the deflector plate back and open a balanced valve the full size of the steam connection, thus instantly admitting the full force of the steam into the flue. With the steam confined close to the end of the flue, opening the valve suddenly produces an effect similar to that of a powerful blow. The steam cannot escape from the head except when the cleaner is pressed against the flue and there is, therefore, no escaping steam to dampen the soot and cause it to stick to the flue. The cleaner is made by the Michigan Lubricator Company.

Fig. 16 shows a steam tube cleaner made with an automatic sliding valve, so arranged that when the blower head is being moved from tube to tube the valve is closed and so prevents the escape of steam. The valve is placed in the casing

FIG. 17.

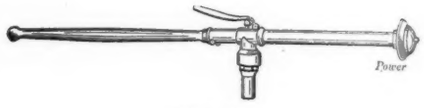


FIG. 18.

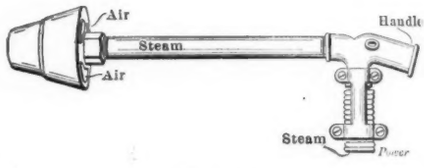


FIG. 19.

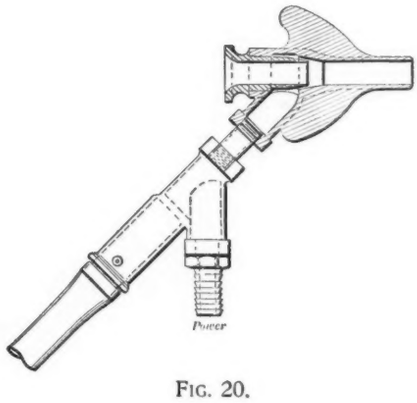


FIG. 20.

A just back of the head. When the head is inserted in a tube a slight pressure on the handle causes the pipe to slide on the valve, exposing the ports, thus admitting steam to the tube through the slot in the head.

A type of sand-blast tube cleaner is shown in Fig. 17. A jet of steam is introduced into the head of the cleaner, creating a partial vacuum in the head which draws in fine sand. The combination blast of steam and sand is blown through the tubes with great velocity, thereby removing the soot and acting as a blower and scraper combined.

What is known as the "Red Jacket" steam flue blower is shown in Fig. 18. The steam is controlled by means of the valve and lever shown. The blower head is made with a rounding face which closely fits to the tube opening. When ready to clean a tube, the head is placed at the end and the valve opened by pressing down on the handle. The valve is closed while passing the head from one

tube to another. This cleaner is made by H. W. Caldwell & Son.

The "Success" steam and air flue cleaner, made by Charles Nubring & Brother, is shown in Fig. 19. The soot is removed from the tubes by means of a small jet of steam and a large volume of air introduced simultaneously. The steam heats the blower head so that hot air is drawn into the tubes.

The "Parson" tube blower is shown in Fig. 20. It is manufactured by the Parsons Manufacturing Company. The head

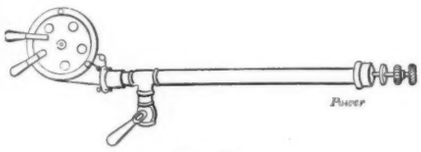


FIG. 21.

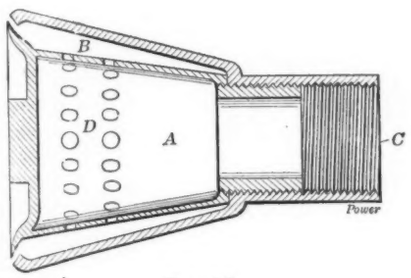


FIG. 22.

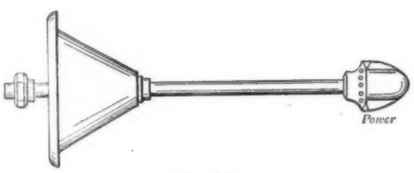


FIG. 23.

is made with two inlets and one outlet. One inlet is for steam, the other for air. The steam enters a chamber surrounding the air-inlet sleeve and, in rushing out around the air-inlet sleeve, forms a partial vacuum. Air is thus drawn into the head where it is mixed with the steam and then discharged through the tube. Owing to the shape of the head, several sizes of tubes can be blown with the same head.

The old "Ball" cleaner differed considerably from the ordinary type of cleaner, and is shown in Fig. 21. It does not use steam as a cleaning agent, but utilizes it as a motive power to operate the two sets of rotating scrapers shown. These scrapers are attached to hubs which revolve in opposite directions, the centrifugal force throwing the scraper out against the surface of the tube. The end of the scraper is inserted in the tube, and the gasket near the end forms a steam-tight joint. Steam is admitted through the valve shown, and passing through and around a perforated follower disk shown back of the scrapers causes the latter to rotate rapidly in opposite directions and at the same time forces them through the tube as fast as the operator pays out a flexible steel ribbon from the reel. This ribbon passes through a stuffing box in the end of the cleaner and is attached to a short rod which carries the disk and scrapers, and serves to withdraw them when wound upon the reel.

Another design of steam cleaner is shown in Fig. 22. It consists of an inner cone-shaped section *A*, which is secured to an outer shell *B*, the outside diameter being such that a close fit to the tube is obtained. Steam enters the inner section *A*, through the inlet *C*, and escapes through the holes *D*, to the space between the inner and outer shells. In the front end of the head between the adjacent edges of these two sections is formed an annular series of steam outlets which incline outwardly and forwardly, so as to direct jets of steam against the boiler tube just in advance of the scraper head.

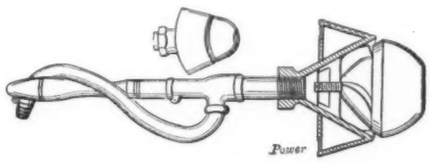


FIG. 24.

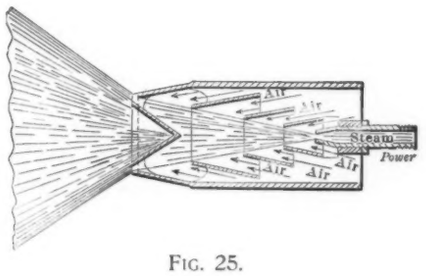


FIG. 25.

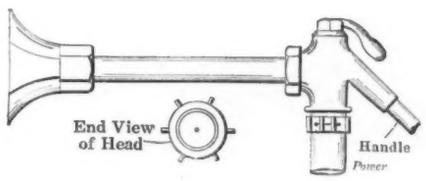


FIG. 26.

A design of soot cleaner, known as the "Vulcan," made by the Corbett Supply Company, is shown in Fig. 23. The cleaner is connected with a live-steam pipe, and is relieved of all condensation prior to entering the tubes of the boiler. In the head of the cleaner are small counterbored apertures, which aid in relieving condensation and also in causing an agitation of soot in the tubes as the cleaner is placed in them.

The tube cleaner is admitted into the tube for about 6 inches, until it strikes a shield which acts as a valve and drives the steam to the rear end of the tube, causing considerable agitation for its full length. By gently pulling out, the vacuum that is formed cleans the tube of soot and accumulation.

It is claimed that the steam is superheated and that it is utterly impossible to cause contraction, due to cold air entering the tubes or parts of the combustion chamber of the boiler. It is said that the cleaner will work in a very satisfactory manner with a steam pressure of from 10 to 15 pounds.

The A and D steam cleaner is shown in Fig. 24. It is made by the Cleveland Flue Cleaner Manufacturing Company. Owing to its design, a spiral motion is given to the jet of steam as it leaves the head. The outer surface of the head is

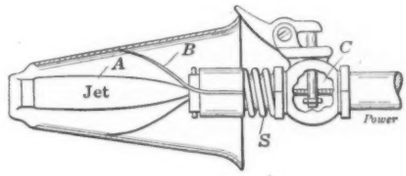


FIG. 27.

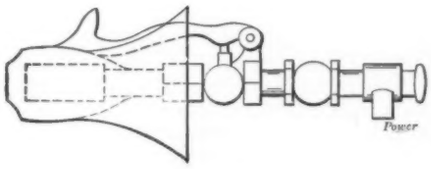


FIG. 28.

turned true so that it fits nicely to the tube end. The sectional view of the head shows the general design.

The "Tornado" cleaners, made by the Paul B. Huyette Company, is illustrated in Fig. 25. Owing to its design a large amount of air is admitted to the head when blowing a tube, thus reducing the amount of steam used. A steam jet is placed as shown, and with the truncated-cone arrangement shown in the illustration produces a vacuum when steam is turned on, thus creating a current of air containing but little moisture. The air and steam current is directed by the inverted cone at the front end of the cleaner against the inner wall of the tube for its entire length.

An improved steam blower, made by the Sherwood Manufacturing Company, is shown in Fig. 26. It is so designed that the flow of steam is not retarded in passing through the head. The device is fitted with a valve for turning on and off the steam. The same type of blower is also made for vertical boilers.

An early design of cleaner designated as the "Hurricane" is illustrated in Fig. 27. The main feature was that of admitting a jet of steam through the center of the head. A current of air was introduced through the bell-shaped nozzle *B*, and was thereby given a rotary motion by the spiral curved plate *A*. The rotating column of air and steam entered the tube, the idea being to produce the whirling action of a miniature hurricane to remove the soot. The large amount of air in proportion to the volume of steam

prevented any objectionable amount of condensation to form a paste and bake upon the surface of the tubes.

The bell head was held in position by a catch attached to the same plate that imparted the spiral motion to the steam

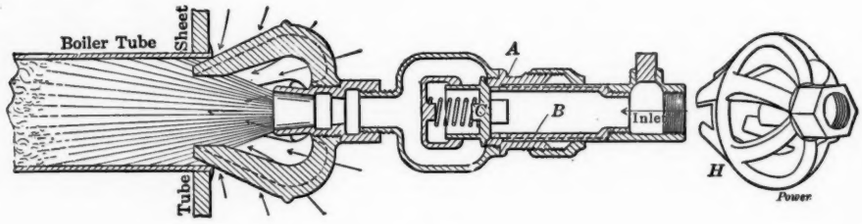


FIG. 29.

current. It could be easily detached, exposing the interior of the jet for cleaning. *A* and *B* were held in place by a collar which was retained in position by a short spiral spring *S*. When the bell was placed in a tube and forced against the tension of the spring its edge operated a lever and opened the valve *C*. Relieving the pressure with which the cleaner head was held against the tube automatically shut off the steam, when changing from one tube to another.

Fig. 28 shows another design of the same cleaner, the difference being in the operation of the valve. The lever operating the valve stem is extended on the outside of the head, and as the cleaner is forced against the tube, the lever is depressed, thus opening the valve. It is made by James L. Roberston & Sons.

The "Claflin" cleaner is shown in Fig. 29. The skeleton head is provided with six extending prongs which are ribbed on the inside. A divergent tapering steam nozzle passes through the center of the head. When the cleaner is in operation a partial vacuum is formed behind the nozzle by the rapid longitudinal expansion of the steam passing through the tube. The air is thus induced through the prongs in large volume, which relieves the vacuum by equalizing the atmospheric pressure at both ends of the tube.

The cleaner is used in conjunction with a telescopic automatic balanced valve, shown attached to the head. This valve

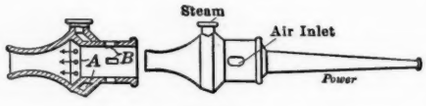


FIG. 30.

will work on any steam pressure up to 120 pounds. When the cleaner head is forced against the tube the cylinder *A* slides on the plunger *B*, thus opening the balanced valve *C*, which is automatically closed by the steam when changing from one tube to another. This gave the advantage of having steam at full boiler pressure confined within a few inches of the end of the tube.

Fig. 30 illustrates an early type of the Grime injector cleaner. Steam is admitted into an annular chamber *A*, from which it escapes through small holes toward the mouth. The current of steam coming from these holes induces an air blast through the central pipe, shown in the sectional view of the head. The air enters through the holes *B*. The velocity of the escaping steam is communicated

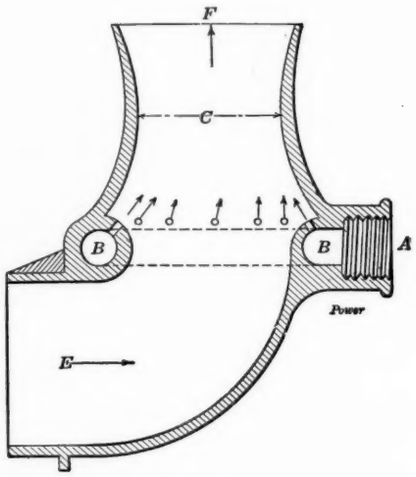


FIG. 31.

to the air, the idea being to reduce the amount of steam used in proportion to the work performed. The cleaner consists of one piece, has no movable parts, and the nozzle is so shaped that it can be used on tubes of from 2 to 4 inches in diameter.

The cleaner shown in Fig. 31 differs from the ordinary tube cleaner, in that the soot instead of being blown out of the tubes into the back connection is drawn by a partial vacuum from the rear end to the front without admitting steam into the tubes.

The device operates on the injector principle; steam, being admitted at *A* and passing to the circular chamber *B*, is admitted to the small holes shown. As the tube is smaller at *C*, considerable velocity is given to the steam and a strong suction is produced at the end *E* which is held against the tube end. This draws the soot out of the tube and, passing through the cleaner, it is discharged through the end *F* to the smoke flue.

An improvement to the head illustrated in Fig. 31 is shown in Fig. 32. It consists of a plug in the steam ring so that in case pieces of rubber hose are blown into the chamber the plug can be unscrewed and the obstruction removed. This improved soot cleaner is made by the John S. Bushnell Company.

Fig. 33 illustrates a "Thompson" soot ejector made by Richard Thompson & Co. Steam is discharged from the central tip, creating a vacuum which draws the soot out of the tube and ejects it up the stack. Its inner construction is shown in the sectional view of the illustration.

A handy device for blowing the tubes of an upright boiler is shown in Fig. 34. It consists of a head having a hollow center through which the steam emerges. On the outside of the head three ribs are cast lengthwise for the purpose of centering the head. At a point on the horizontal rod at a sufficient distance from the elbow to allow the head to reach the

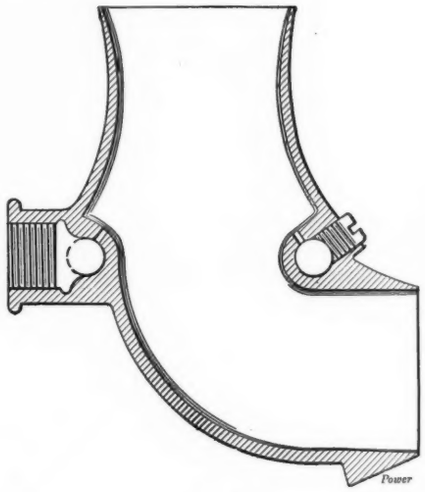


FIG. 32.

innermost tube, is a hinged joint. This joint allows of swinging the blower head up and down when changing from one tube to another. The hinged section is fitted to a hollow stand and is held in place after being adjusted by a set screw. The adjustable feature permits of the device being used on boilers of different

FIG. 33.

sizes. This blower was designed by F. R. Low.

A variation of the type of cleaner illustrated in Fig. 11 is shown in Fig. 35. The only difference is that it is vertically mounted on a pipe, as shown, and is for use with upright boilers.

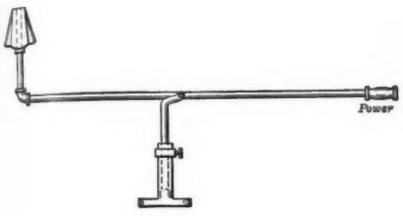


FIG. 34.

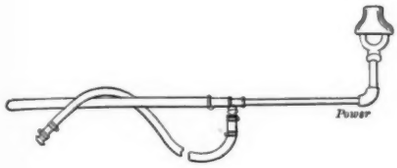


FIG. 35.

Fig. 36 shows the cleaner illustrated in Fig. 24, arranged for use with vertical boilers.

The tube blower shown in Fig. 37 is of the same design as that shown in Fig. 4, but is mounted on a pipe for blowing the tubes of vertical boilers.

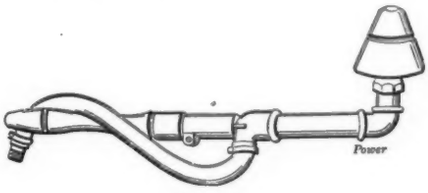


FIG. 36.

Fig. 38 shows the same design of blower as appears in Fig. 10, arranged for blowing tubes of a vertical boiler.

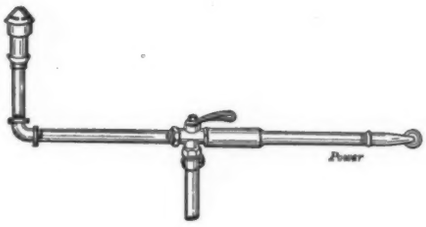


FIG. 37.

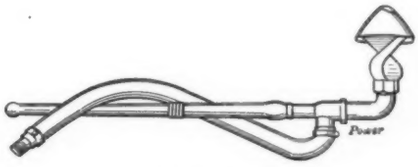


FIG. 38.

Engineer's Problem in Selecting Coal

By George H. Bayne

In a previous contribution under the above caption the author discusses the purchasing of coal upon the basis of actual boiler performance. In the present article a standardization test with three kinds of coal is given and sample computations are worked out, upon which the final selection is based.

A large manufacturing plant whose annual consumption runs into thousands of tons of bituminous coal, decides that the purchasing of its fuel shall be placed upon a more definite basis and that the coal shall be bought upon its value to them, irrespective of analyses and the statements of the several coal companies involved. To this end they institute a policy whereby their coal shall henceforth be bought through coöperation between the purchasing agent and the engineer in charge of the plant, the purchasing agent to determine from a business standpoint the relative values of the coals submitted to him and the engineer to test these to determine their actual values under his particular conditions, after which the two together can arrive at a conclusion as to which of the several kinds of coal submitted is the most economical.

The purchasing agent lets it be known to the different coal companies who are selling coal in his district that his concern is in the market for 25,000 tons of "run of mine" bituminous coal, clearly stating his requirements as to delivery, payments, etc., specifying that the coal which he wishes the companies to bid upon shall be free from slate and bone and shall not be slack; and that the coal shall be guaranteed to maintain the following analysis: volatile, 18 to 25 per cent.; ash, 6 to 10 per cent.; sulphur, 1 to 2 per cent.; B.t.u., dry, not less than 14,250. To this inquiry some fifteen coal companies put in their bids, together with a guaranteed analysis. After investigating these the purchasing agent cuts down the number of probable successful applicants to three, which, for convenience, may be designated as Nos. 1, 2 and 3. No. 1 bases his offer on coal mined from the *C*-prime vein of the patent field in the Clearfield district of Pennsylvania. No. 2 offers a coal of the *B* vein from the South Fork district of Cambria county. No. 3 proposes to furnish a coal from the *D* vein from Indiana county, Pennsylvania. The freight rate into the plant from all three of these districts is $1.85, so Nos. 1, 2 and 3 offer these coals, delivered to the plant, at $2.95, $3 and $2.85 per ton, respectively.

Having reached this point, the purchasing agent orders a sample car from each of these three companies for test purposes and turns them over to his engineer to decide which is the best for the plant under its existing circumstances. This is as far as the purchasing agent can go for the present; the proposition is now up to the engineer to determine the commercial efficiency of the three grades under consideration for this plant.

The boiler plant under his charge consists of two 520- and eight 264-horsepower Aultman-Taylor water-tube boilers equipped with shaking grates, hand fired and using natural draft. In preparation for the test the engineer designates one boiler in the line for test purposes, and for a matter of convenience takes one of the 264-horsepower units. This boiler is carefully cleaned, the tubes are blown and the furnace thoroughly repaired; the brickwork is pointed up and put in good condition; and the feed-water line is bypassed and connected to the auxiliary feed-water pump. As it is impracticable in this plant to weigh in barrels the water entering the boiler, a Worthington duplex hot-water piston meter is installed in the line between the pump and the boiler; also the feed-water line is tapped for a thermometer, which is placed as near as possible to the entrance into the boiler. For taking the flue-gas temperatures a pyrometer is placed in the breeching between the damper and the uptake. The stack is tapped and a draft connection made for taking draft readings over the fire in the first pass. Scales of the Fairbanks type are set up in the boiler room, and upon these all coal under test is weighed before being delivered to the fireman; also the blowoff cocks are blanked off in order to eliminate any possibility of leakage from this source. One of the most experienced firemen in the plant is detailed to fire all three of the coals under test.

As this plant operates on an eight-hour day basis, it is decided that each coal shall be given a trial covering this period, which is considered sufficient. Preliminary to starting the test, the three grades of coal are dumped from the cars in three separate piles, which are marked No. 1, No. 2 and No. 3, respectively, and are delivered to the firemen accordingly The engineer then provides himself with a notebook, in which the log of each test is to be recorded; this can be conveniently arranged in the following manner:

GENERAL DATA.

Number of boiler used.....
Name of fireman.....
Kind of coal (anthracite or bituminous).....
Supplied by.....
Car number.....

Number of test.....
Duration of test.....hours.....
Date of test.....
State of weather (clear, cloudy, rain or snow).....

COAL.

Size and condition (slack, run-of-mine or screened, well prepared or dirty).....
Total weight of coal fired during test.....
Percentage of moisture in coal by weight.....
Total ash and refuse.....
From fire box.....
From ashpit.....
Nature of clinker (hard or soft, large or small).....
Thickness of fire required and bar work necessary.....
Method of firing (spreading, alternate or coking)..

WATER.

The total weight of water fed the boiler during the test.....
(If a meter is used, this will be the difference between the initial and the final readings of the meter, corrected for the temperature of the feed water, and should be calculated in pounds.)

PRESSURES.

Barometer (if a barometer is not available, 14.7 pounds per square inch is correct for all practi- puposes).....
Steam pressure by gage per square inch.....
Draft at stack.....
Draft in furnace, over fire.....
Draft in ashpit (this is only necessary when forced draft is used).....

TEMPERATURES.

Temperature of feed water entering the boiler.....
Temperature of escaping gases (pyrometer).....

The percentage of moisture in the coal is found by placing 10 to 20 pounds of the coal in a galvanized-iron bucket, or preferably a dish pan, which is placed on top of the boiler at the hottest point and is allowed thoroughly to dry out. This will take between ten and twenty-four hours, according to the moisture that is in the coal. The difference between the initial and the final weights of the coal reckoned as a percentage of the moist coal is taken as the moisture in the coal, as delivered to the boiler room.

This done, the next point to take into consideration is the calibration of the meter, which is very important. A barrel is placed on the scales, which are set to compensate for the weight of the barrel. The meter is allowed to discharge into the barrel until the latter is full and the temperature of the water is taken during the process of filling. The barrel of water is then weighed and the difference between the initial and the final readings of the meter is noted and the amount of water passed through the meter, corrected for its temperature, is calculated. This resu' should coincide with the weight of the water in the barrels. The process is repeated at least five times, from which the average result is determined. The difference between the readings of the average weight in the barrels and that shown by the meter, when figured in per cent., gives the correction that has to be allowed, either plus or minus, to the total amount of water as shown by the meter to have been fed to the boilers during the test. For example, suppose that ten barrels of water have been drawn through the meter and found to weigh on the scales 3420 pounds. The first reading of the meter indicated 540 cubic feet and the final reading 600 cubic feet; in other words, 60 cubic feet have passed through the meter, according to the readings. Now the average temperature of the feed water was 203 degrees Fahrenheit. The weight of a cubic foot of water at 203 degrees is 60 pounds per cubic foot; therefore, the total number of pounds of water passed through the meter was

$$60 \times 60 = 3600 \textit{ pounds.}$$

The actual weight in the barrels showed 3420 pounds; therefore the meter was evidently reading fast by 180 pounds, and the percentage of overreading is

$$180 \div 3420 = 0.052 = 5.2 \textit{ per cent.}$$

Hence the total amount of water, as registered by the meter, should be multiplied by 0.948 in order to obtain the correct reading. If, on the other hand, the meter had been found to read low by 5.2 per cent., it would be necessary, in order to obtain the correct reading, to divide by 0.948.

Smoke

The engineer from time to time should observe the smoke issuing from the stack and note the quality on his log. This is essential when the plant is situated in a residential district or where a smoke ordinance is enforced.

All the readings of temperatures and pressures are taken every half hour during the test. With these points in hand, the engineer starts to test the coals, testing each grade separately and taking every precaution to have the load factor as nearly constant for each grade as possible. Using the alternate method of starting and stopping the test, as explained in a previous article under the same caption by the writer, the following comparative results are obtained:

Economic Comparison between Coals Nos. 1, 2 and 3.

Kind of Boiler—Aultman-Taylor.

Kind of Fuel—No. 1, No. 2, No. 3.

Kind of Furnace—Hand fired; shaking grates.

State of Weather—For No. 1, rainy; No. 2, clear; No. 3, rainy.

Method of Starting and Stopping Test—Alternate.

Number of Boilers Tested—One.

Type of Boiler—Water-tube.

Date of Trials—

Duration of Trial—Eight hours for each grade of fuel.

DIMENSIONS AND PROPORTIONS.

	Total.
Grate surface, square feet	63.75
Width of grate	8 feet, 6 inches.
Length of grate	7 feet, 6 inches.
Kind of draft	Natural
Water-heating surface, square feet	2640
Superheating surface	None.
Ratio of water-heating surface to grate surface	41.4 to 1

AVERAGE PRESSURES.

Barometer, inches of mercury.....Not taken.

	No. 1	No. 2	No 3.
Steam pressure by gage, pounds per square inch.	143	149	133

DRAFT.

Draft between damper and boiler, inches of water..	0.35	0.38	0.34
Draft in furnace, inches of water.....	0.23	0.24	0.27
Draft in stack, inches of water.....	0.8	0.8	0.8

AVERAGE TEMPERATURES.

Gases escaping from boiler, degrees Fahrenheit.....	525	540	580
Feed water entering boiler, degrees Fahrenheit....	96.6	117.1	88.00

FUEL.

Size and condition.....	Run-of-mine, well prepared.		
Total weight of coal fired, pounds.....	9323	9170	7180
Moisture in coal (actual), per cent.....	5	3.1	2.34
Total weight of dry coal consumed, pounds.....	8857	8886	7012
Total weight of ash and refuse, pounds.....	854	942	812
Ash and refuse in dry coal, per cent.....	9.64	10.61	11.58
Total combustible consumed, pounds.....	8003	7944	6200

FUEL PER HOUR.

Dry coal consumed per hour, pounds.....	1107.1	1110.7	876.5
Combustible consumed per hour, pounds.....	1000.4	992.9	775

PROXIMATE ANALYSES OF COALS.

Moisture, per cent.....	2.6	1.7	1.2
Volatile matter, per cent...	24.2	17.3	23.0
Fixed carbon, per cent...	70.1	73.1	68.5
Ash, per cent.....	5.7	9.6	8.5
	100.00	100.00	100.00
Sulphur, separately determined, per cent.....	1.29	1.64	1.55
Color of Ash.....	Yellowish gray	Yellowish gray	Bluish gray

CALORIFIC VALUE OF FUEL.

Calorific value of coal per pound as received.....	14,433	13,944	14,380
Calorific value of dry coal per pound, B.t.u.....	14,795	14,236	14,782

WATER.

Total weight of water fed to boiler, corrected for meter calibration, pounds	79,223	76,997	56,199
Equivalent water evaporated into steam from and at 212 degrees, pounds..	92,231	88,054	65,854
Factor of evaporation.	1.1642	1.1436	1.1718
Equivalent water evaporated into steam from and at 212 degrees per hour, lb ..	11,529	11,006.8	8,231.7

ECONOMIC EVAPORATION.

Equivalent water evaporated per pound of dry coal from and at 212 degrees, pounds.....	10.41	9.91	9.39
Equivalent water evaporated per pound of combustible from and at 212 degrees, pounds.....	11.52	11.08	10.62

RATE OF EVAPORATION.

Water evaporated from and at 212 degrees per square foot of heating surface per hour, pounds	4.37	4.17	3.12

RATE OF COMBUSTION.

Dry coal consumed per square foot of grate surface per hour, pounds..	17.36	17.42	13.74

HORSEPOWER.

Builders' rating at 10 square feet of water-heating surface per horsepower, pounds.....	264	264	264
Horsepower developed (34½ pounds of water evaporated per hour from and at 212 degrees = one horsepower.....	334.1	319.04	238.6
Percentage of overrating developed.....	26.55	20.84	9.62 (underrating)

EFFICIENCY.

Efficiency of the boiler, including the grate, per cent.....	67.62	67.55	61.64

METHOD OF FIRING.

Kind of firing	Coking	Coking	Coking
Average thickness of fire	8′ 10″	6′ 10″	7′ 8″

ECONOMIC RESULTS.

Cost of coal per gross ton delivered	$2.95	$3.00	$2.85
Estimated gross tons of coal required	23,938.9	25,146.7	26,539.3
Estimated cost of coal per annum, based on price per ton	$70,618.75	$75,440.10	$75,637.00
Estimated cost of ash removal	$0.20 per gross ton		
Estimated total cost of ash removal, based on percentage of ash in coal	$461.54	$533.61	$614.65
Total estimated cost of coal per annum, including ash-removal charges	$71,080.29	$75,973.71	$76,251.65
Net difference per annum, in favor of No. 1 over No. 2 and No. 3	.....	$4,893.42	$5,171.36

Before going into the discussion as to the relative merits of the three grades of coal under consideration, it would be well to consider how the engineer has arrived at the results, as tabulated. During the test he has observed the average temperatures, pressures, the amount of fuel delivered, the amount of ash obtained and the amount of water evaporated by the boiler, and has recorded these upon his log sheet. The method of determining the moisture in the coal has been explained, and this moisture was found to be 5 per cent. by actual weight in sample No. 1. Therefore, the total weight of dry coal consumed is the total weight of coal fired, less the moisture; that is,

$$9323 \times 0.95 = 8857 \textit{ pounds.}$$

The total ash and refuse, as shown by the log, was 854 pounds; hence the percentage of ash and refuse in the dry coal is

$$854 \div 8857 \times 100 = 9.64 \textit{ per cent.}$$

The total combustible consumed is the total dry coal less the ash and refuse:

$$8857 - 854 = 8003 \textit{ pounds.}$$

The weight of dry coal consumed per hour is

$$8857 \div 8 = 1107.1 \textit{ pounds.}$$

The next thing necessary is to find the factor of evaporation, which is in proportion to the steam pressure and the temperature of the feed water and is calculated in the following manner:

$$\textit{Factor of evaporation} = \frac{H_1 - H_2}{970.4}$$

where

H_1 = Total heat of the steam at the gage pressure (reckoned above 32 degrees Fahrenheit);

H_2 = Total heat in the feed water at the observed temperature, reckoned above 32 degrees Fahrenheit;

970.4 = Latent heat of vaporization at 212 degrees.

From the latest steam tables H_1 is found to equal 1194.3, for case No. 1, and H_2 is 64.6; therefore,

$$\frac{1194.3 - 64.6}{970.4} = 1.1642 = \textit{Factor of evaporation}$$

The equivalent water evaporated into steam from and at 212 degrees equals the total weight of water fed to the boiler multiplied by the factor of evaporation. This with coal No. 1 would be

$$79{,}223 \times 1.1642 = 92{,}231 \textit{ pounds.}$$

The equivalent evaporation into steam from and at 212 degrees per hour is equal to

$$92{,}231 \div 8 = 11{,}529 \textit{ pounds.}$$

The equivalent water evaporated per pound of dry coal from and at 212 degrees is equal to the total amount of water evaporated from and at 212 degrees divided by the total amount of dry coal consumed:

$$92{,}231 \div 8857 = 10.41 \textit{ pounds.}$$

The equivalent water evaporated per pound of combustible from and at 212 degrees is found by dividing the equivalent water evaporated into steam from and at 212 degrees by the total combustible consumed:

$$92{,}231 \div 8003 = 11.52 \textit{ pounds.}$$

The rate of evaporation, or the amount of water evaporated from and at 212 degrees per square foot of heating surface per hour, is found by dividing the equivalent water evaporated into steam from and at 212 degrees per hour by the number of square feet of heating surface in the boiler:

$$11{,}529 \div 2640 = 4.37 \textit{ pounds.}$$

The rate of combustion, or the dry coal consumed per square foot of grate surface per hour, is the total amount of dry coal consumed per hour, divided by the number of square feet of grate surface in the furnace:

$$8857 \div 63.75 = 17.36 \textit{ pounds.}$$

Thirty-four and a half pounds of water evaporated per hour from and at 212 degrees Fahrenheit has been set as the standard for one boiler horsepower. Therefore, the boiler horsepower developed per hour is equal to the equivalent water evaporated from and at 212 degrees per hour, divided by 34½ which is

$$11{,}529 \div 34\tfrac{1}{2} = 334.1 \textit{ horsepower.}$$

The percentage of overrating developed is the horsepower developed, multiplied by 100, divided by the builders' rating, minus 100:

$$\frac{334.1 \times 100}{264} - 100 = 26.55 \textit{ per cent.}$$

The efficiency of the boiler, figured in per cent., including the grate, is the evaporation per pound of dry coal from and at 212 degrees, multiplied by 970.4, and divided by the calorific value per pound of dry fuel:

$$\frac{10.41 \times 970.4}{14{,}795} = 67.62 \textit{ per cent.}$$

Having figured out the results of the test the engineer is ready to determine which of the three grades of coal is the most economical for him to use. He has a 3152-horsepower plant and estimates that in order to run this plant for one year of the required number of hours, including the holidays, shutdowns, etc., that it will require the evaporation of 558,218,209 pounds of water *per annum*. Therefore, he uses this as an arbitrary basis of comparison for the three coals. Coal No. 1 evaporates 10.41 pounds of water per pound of coal, from which he finds that 23,938.9 gross tons of this grade would be required:

$$558{,}218{,}209 \div (10.41 \times 2240) = 23{,}938.9 \textit{ gross tons.}$$

In a like manner he calculates that with coal No. 2 25,146.7 gross tons would be required, and with No. 3 26,539.3 gross tons. Figuring the costs of these three grades at their respective prices, the estimated gross cost of operating this plant, irrespective of firing charges and fixed expenses due to repairs, etc., would be $70,618.75 for No. 1; $75,440.10 for No. 2, and $75,637 for No. 3.

By previous experience, the engineer finds that the cost for ash removal is $0.20 per gross ton. Therefore, inasmuch as Nos. 1, 2 and 3 have, respectively, 9.64, 10.61 and 11.58 per cent. of ash and refuse, the approximate cost of ash removal that should be expected for the three grades of coal would be $461.54 with No. 1; $533.61 with No. 2, and $614.65 with No. 3. This makes a total net cost of the three grades of coal respectively, $71,080.29, $75,973.71 and $76,251.65. In other words, the engineer finds that by the use of coal No. 1 his estimated saving will be $4893.42 over No. 2 and $5171.36 over No. 3. When referring to his log he also finds that, as compared with No. 1, No. 2 and No. 3 have required more bar work and more attention from the fireman, which leads him to believe that the two latter coals would cause more damage to the brickwork and grate bars than the former. Also, upon an examination of the guaranteed analyses, as submitted by the competing coal companies, he finds that the sulphur and ash are higher in No. 2 and No. 3 than they are in No. 1. Again, by referring to the prices he notes that it is not the highest, nor the lowest, but the medium-priced coal that is best suited to his purposes; therefore he recommends to the purchasing agent that the contract for the fuel supply be placed for No. 1 coal.

Electrical Department

Care and Maintenance of Induction Motors

By R. H. Fenkhausen

Especially conducted to be of interest and service to the men in charge of the electrical equipment.

Notwithstanding the fact that the best types of modern induction motors are advertised as being almost indestructible, and are in fact marvelously rugged and trouble-resisting, it will be found that continued neglect, careless oiling and overloading will eventually cause such deterioration that extensive and costly repairs will be imperative and, unless spare motors are available, will cause much loss of time and money due to idle machinery and reduced output. As a general rule it will be found that ten cents expended in intelligent and systematic inspection of electrical equipment will mean a saving of from five to ten dollars in repairs later on.

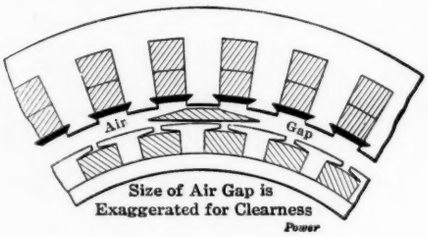


Fig. 1. Airgap Gage

This statement applies particularly to large motor installations in which one man can be detailed for motor inspection and his salary divided among so many motors that the cost per motor is small.

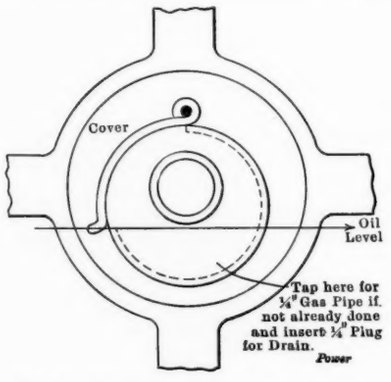


Fig. 2. Usual Form of Oil Well

The repair bill alone on one motor burnout would often pay the man's wages for a month, to say nothing of the loss due to the shutdown.

In a plant that once came under my supervision no system of motor maintenance was applied. The motors were oiled by the various department oilers and ordinary red machine oil was used. No attention was given to motors until they gave signs of distress, whereupon they were shut down and taken to the shop, where several repair men were constantly at work. Shutdowns were numerous and maintenance costs high due to costly repairs.

A careful investigation disclosed the fact that two causes were responsible for about nine-tenths of the motor troubles, namely, careless oiling and worn bearings. The first cause was also largely responsible for the second, owing to the poor quality of oil used. The first change made was to take the motor lubrication out of the hands of the various department oilers and make one man responsible for all motors. This did not necessitate an extra man because when released from motor oiling, each oiler was enabled to cover a larger territory and one was laid off. The man selected for motor maintenance was an electrical helper of the better class, and received $2.75 per day. He was furnished with a good quality of light engine oil, often called dynamo oil, and instructed to use nothing else.

All the motors in the plant were listed and divided into five groups, one of which was to receive attention each day. The sixth day was kept as a "catch-up" day, in case a serious breakdown necessitated the man's assistance for a day in the repair shop. The motors were in such dirty condition that a man and helper from the shop were detailed to overhaul all of them, one at a time. The work was done without removing the motors and with a very slight interruption of service, as only a day was required, on the average, for each motor. The motors were completely dismantled and washed clean with gasolene, special attention being given to the bearings, oil wells and oil-soaked coils. After being thoroughly cleansed of all oil, the windings were given two coats of a waterproof insulating varnish; this varnish was liberally applied, and was insoluble in oil. The bearings were tried and if worn were replaced with spares from stock. The motor was then reassembled, the oil wells filled with new oil and finally two coats of green enamel were put on the entire frame of the motor. This was done because it improved the appearance of the machine, and experience has shown that a nice-appearing machine will receive attention whereas an equally clean but less attractive one will be neglected. The motor inspector on his regular rounds kept the oil wells filled, tested the airgaps, wiped off the motor all over and inspected all starter contacts and controller fingers.

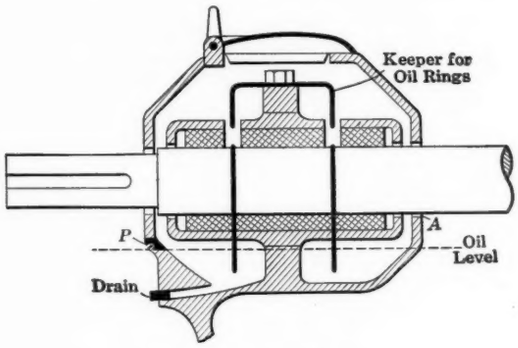


Fig. 3. Old-style Box

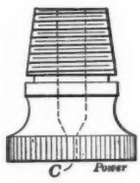


Fig. 4.

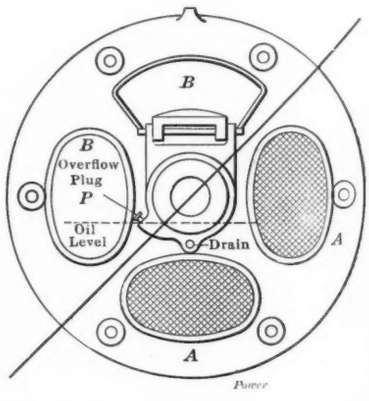


Fig. 5. "Open" and "Ventilated" Forms

From the very start it was possible to reduce the shop force and at the end of four months when all the motors were overhauled there was not one man engaged on motor repairs in the entire plant. One man now keeps up the entire motor equipment, and only six motors have been to the repair shop in four years; all of these were motors that had been oil-soaked before the new system was

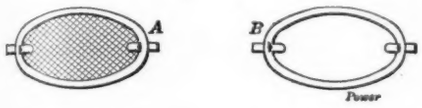


FIG. 6. COVERS FOR FRAME OPENINGS

adopted. No appreciable wear has occurred in any of the motor bearings, except those in such locations as required short vertical belt drives. These are being replaced with chain drives as rapidly as conditions permit; short vertical belt drives are poor engineering and are indefensible in most cases.

In testing airgaps, two gages are used irrespective of motor sizes. If the large one will not enter at four equidistant points, the motor is listed for new bearings at the first opportunity, but if the small gage will not enter, the machine is immediately shut down. The most serious trouble about bearing neglect is that if the rotor is allowed to come in contact with the stator the heat caused by friction usually burns up all the insulation on the rotor bars and on as many stator coils as are included in the arc of contact between the rotor and stator. The stator coils, of course, require renewal, but if the rotor insulation is evenly burned the rotor may be allowed to run, as one of the principal uses of the slot insulation on a squirrel-cage rotor is to hold the bars tightly and prevent vibration, and the absence of insulation would merely lessen the resistance of the rotor and therefore decrease its starting torque slightly. As a rule, however, the rotor insulation burns unevenly and the bars should therefore be reinsulated to prevent electrical and mechanical unbalancing.

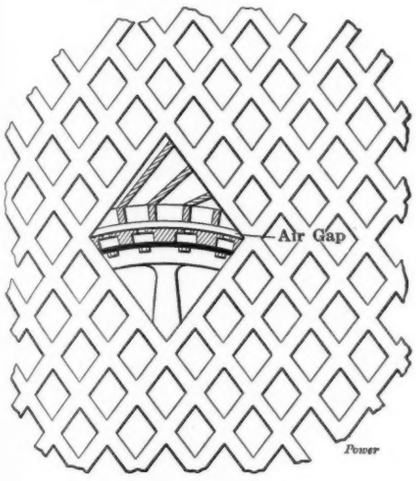


FIG. 7. ACCESS TO AIRGAP THROUGH GRATING

If an airgap gage is not furnished by the motor manufacturer one should be made of spring steel and ground to the shape shown in Fig. 1.

When a motor shaft becomes reduced in diameter due to excessive wear, it should not be turned down unless it is in the only motor of the size in the plant. It is better to make a new shaft and keep up the standard size so that one pair of spare bearings will answer for all motors of the same original shaft size.

Careless filling of oil wells leads to oil being spilled on the windings and, in spite of varnish or other oil-resisting compounds, the oil will eventually work its way into the coils where it leads to insulation breakdowns and short-circuits. Most modern motors have oil wells similar to Fig. 2, which prevent overfilling, but the older types were equipped with oil wells like Fig. 3 and if oil was poured into the wells without removing the filling plug *P* the oil would overflow at *A* and drip down on the windings. To prevent this the plugs may be left out all the time but owing to the inevitable entrance of dust, it is better to drill and counterbore the plug as shown in Fig. 4; then excess oil will spurt out with considerable velocity at *C*.

The old "Type C" Westinghouse motors, of which many thousands are still in use, were equipped with heads having ventilating grids cast integral with the heads, as shown at *A* in Fig. 5. This construction renders inspection and cleaning very difficult and prevents the insertion of an airgap gage. These grids should be broken out and the openings filed smooth, as shown at *B*, Fig. 5. This was done to over a hundred motors in the plant under my charge, and besides facilitating cleaning and inspection it has increased the load the motors can carry without overheating, owing to the increase in ventilation secured.

It will be found that the air drawn through the motor by the fans on the rotor carries considerable dust along with it, and this dust is intercepted by the arms of the rotor spider and thrown against the inside of the rotor laminations by centrifugal force. It cannot be successfully removed with the grids in place, even by means of compressed air, and several motors were found with the rotors packed solid with dust, which was baked hard. Of course, these motors ran cooler after being cleansed than they did before.

Motors installed on the floor in our plant, or where there is liability of chips being drawn into them, are fitted with removable ventilating covers held by thumb latches, as illustrated at *A*, Fig. 6, and motors exposed to the weather are provided with solid covers, as at *B*, Fig. 6, backed with rubber gaskets. Motors of over 50 horsepower would have been seriously weakened by removing the grids, so diamond-shaped handholes were cut in each grid opposite the airgap, as shown in Fig. 7. As most modern induction motors are constructed to permit access to the interior for cleaning without removing the heads, the foregoing remarks are not applicable to them.

Many induction motors are fitted with terminal blocks like Fig. 8, in which the wire is held in a drilled hole by the pressure of a set screw. The danger of this type of contact has been pointed out in a previous article; for motor service it is particularly bad, owing to the liability to short-circuit by accumulated dust or by accidental contact with chain tackles, etc. Fig. 9 shows a method by which motor terminals may be made to conform to the latest practice. Knife-blade connectors are used on the leads and the wrapping of twine between the two blocks prevents any strain from coming on the motor winding.

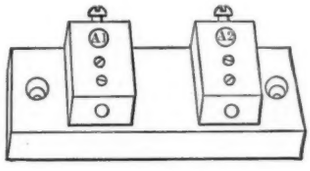


FIG. 8. MOTOR TERMINALS

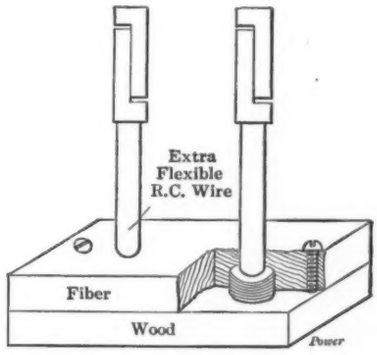


FIG. 9.

Old Pete Blowoff got drunk agin a spell ago an' got ter monkeyin' with th' valve gear uv his ingin. After he'd got dun he put th' indycater on it an' took off a keerd, sent it in t' th' POWER fellers an' ast them what they thot uv it.

"Bill" Bangor writ back an' told him thet it looked jist like th' Stand Patter's perlitical map uv New Yark after Teddy Roosfelt hed got dun wipin' his feet on it up at Saratogy.

LETTERS

How Can One Identify Alternating or Direct Current

Can any of my fellow readers give me a simple and reliable means of finding out whether the current is direct or alternating from an ordinary lamp socket?

H. PRIESTLEY.

Patea, N. Z.

Drying Transformer Oil

I was interested in Mr. Hunter's articles on transformer oil, in the issues of October 18 and 25. While the chemical process may be applicable to drying out small transformers, I doubt very much that it would prove either expedient or practical with transformers of considerable size. Having served for a time as an engineer of electrical construction, I have had occasion to dry out oil for numerous transformers of from 300 to 2000 kilovolt-amperes capacity. In doing this I have found nothing to compare with steam heat for quickness, thoroughness and cheapness. Steam is used in nearly all stations for either heat or power, but where it is not ordinarily available any portable boiler may be used to supply it during the drying process.

With transformers designed for water cooling, the process is simple. The steam-supply pipe is connected to the water inlet of the cooling system and, by means of the valve in the outlet, about ten pounds steam pressure is kept on the coil. This will dry out the oil in a 300-kilovolt-ampere transformer in from 24 to 36 hours, according to the amount of moisture present. With larger transformers, while the oil is boiling I usually circulate it by means of a small centrifugal pump. In 500 kilovolt-ampere or smaller transformers, an occasional stirring with a long-handled paddle is sufficient.

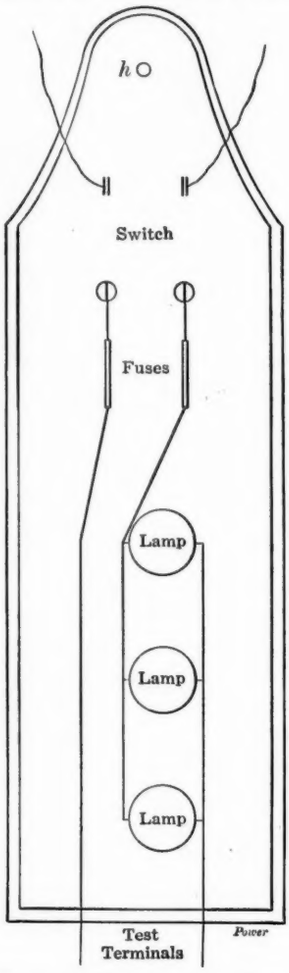
With transformers which do not have cooling coils, I dry out the case and coils by a blast of hot air from a small blower which forces air through a pipe embedded in a "salamander" into the base of the transformer case. To dry the oil I have a light tank large enough to hold about ten barrels of oil. This has a steam coil in the bottom, and the oil is boiled by passing steam through the coil. When the oil is dry it is transferred by the small centrifugal pump to the transformer case, which has been previously dried, and the transformer is ready for service. The tank is portable and taken from one job to another as needed. By using steam there is no danger of overheating the oil, the oil is kept perfectly clean and the only thing to be careful of is that the steam coil does not leak.

EARL R. FILKINS.

Milwaukee, Wis.

Polarity Indicators

The method of testing for polarity, described by R. T. White in a recent issue of POWER, is one which I have used quite often, but to avoid all possibility of a short-circuit I always use as a protecting resistance two or three 16-candlepower lamps, connected in a multiple group, the group being in series with the test terminals. I rigged up a small board, as shown in the accompanying sketch, the board being of a size convenient for carrying it around, and having a hole *h* bored at the top to hang it up by when



GENERAL UTILITY LAMP BANK

not in use. I also find this very handy when it is necessary to reverse the polarity of a dynamo. For this purpose I use only one lamp, and connect to any convenient direct-current 110-volt circuit.

I do not agree with Wesley McArdell's intimation that a potato is a more convenient indicator than the water. The potato is all right, and is generally conceded to be a staple article, but in 10 or 12 years' experience as an engineer I have never happened to be employed in a plant where potatoes were included in the stock of supplies; on the other hand, there is always water available, as well as a container for it.

B. A. SEARLE.

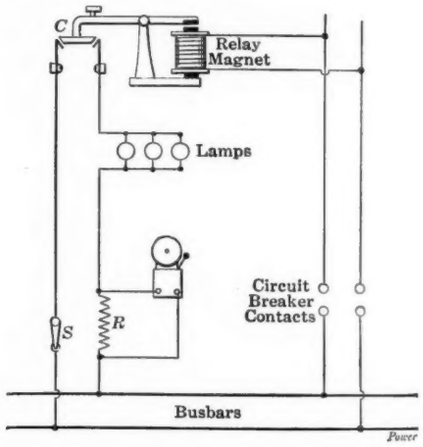
Independence, Colo.

Circuit Breaker Alarms

The circuit-breaker alarm described by Mr. Malcolm in the October 25 issue is open to several objections. To bring live connections onto the insulated handle is not very good policy and would not improve the appearance of the switchboard. The three lamps in series, unless of large size, would not pass enough current to operate the bell, and should one lamp burn out, the alarm would not operate.

Herewith is shown a diagram of an alarm which has no parts on the front of the switchboard and will operate when there is no voltage on the circuit to which it is connected. This arrangement has been in use in a large steel plant for two years and has never failed to operate.

The relay magnet coil is connected across the line terminals of the circuit-breaker and holds the copper bridge *C* out of contact with the alarm-circuit terminals until the main current fails, when



MR. BLOMBERG'S ALARM SYSTEM

the armature will drop the bridge across the terminals of the alarm circuit, permitting the generator to send current through the bell circuit and sound the alarm. By changing the number of lamps in parallel the current may be adjusted to operate any size of bell.

The relay magnet coil and resistance were obtained from an old motor starting box.

A single pole switch *S* cuts the alarm out when desired.

CARL A. BLOMBERG.

McKeesport, Penn.

"Fatty" Dinkelspeil went inter his biler a spell back an' when he tried t' crawl out he got stuck in th' hole. He's bin stickin' 'round there now fer th' last three days an' hez used up all uv th' cuss words in th' dickshunary besides a lot uv his own. He's jist finished th' last uv a dozen bottles uv anti-fat an' sez he thinks thet when he hez tuk a few more thet he kin break loose. "Fatty" is five feet high standin' up, an' six layin' down.

Gas Power Department

Gas Power Plant Costs

By R. S. Manning

What is probably the largest gas-driven station in this country supplying power for electric-railway work is located on the Wisconsin shore of Lake Michigan. The line supplied is about 112 miles long and the service is chiefly interurban.

The station equipment consists of two twin-tandem double-acting horizontal Allis-Chalmers gas engines supplied from Loomis-Pettibone bituminous producers and direct connected to Allis-Chalmers alternators rated at 1000 kilowatts each.

Both the engines and the alternators were designed to carry large overloads and have actually carried in service 1650 kilowatts for a considerable length of time.

The alternators generate three-phase currents at 25 cycles and 405 volts pressure, which is stepped up to 22,000 volts by a bank of seven 500-kilowatt transformers. For supplying nearby sections of the line, two 300-kilowatt rotary converters are used. Exciting current is furnished by two 50-kilowatt dynamos direct connected to three-cylinder vertical gas engines with cylinders 11 inches in diameter and a stroke of 11 inches. The usual switchboard equipment is provided.

Two double-generator sets of down-draft producers make the gas from bituminous coal. The generators are 11 feet in diameter and 18 feet high, the economizer boilers are 6 feet 6 inches in diameter, the wet scrubbers are 9 feet in diameter and the dry scrubbers are 12 feet in diameter and 12 feet high. Each double-generator set is rated at 2000 horsepower, but is capable of considerable overload.

Outside the building is a gas holder having a maximum capacity of 30,000 cubic feet, and this is provided with a 20-inch bypass pipe, with suitable valves.

The entire plant was erected by a firm of engineers whose fee was 10 per cent. of the aggregate cost of machinery, materials and construction, so that the final costs given in the accompanying table are 110 per cent. of the net costs of the installed plant.

The plant was arranged for the installation of a third engine unit of the same capacity and it was estimated that the cost of this unit, including foundation, piping and electric generator, delivered and erected, will not exceed $75,000. The whole station will then have cost $396,673.89 and have a rated capacity of 3000 kilowatts. The cost per kilowatt on rated capacity will therefore be about $132, but the cost per kilowatt on the maximum capacity of at least 1650 kilowatts per unit or 4950 kilowatts total will be about $80.

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men.

INSTALLATION COSTS.

Buildings, both producer and engine:		
Material	$ 24,415.64	
Labor	12,353.15	
Superintendence	370.00	
	37,138.79	
Engineering fee	3,713.88	
		$ 40,852.67
Machinery in engine house:		
Apparatus and material	195,421.01	
Labor	2,133.45	
	197,554.46	
Engineering fee	19,755.44	
		217,309.90
Machinery in producer house:		
Apparatus and material	65,993.07	
Labor	352.24	
	66,345.31	
Engineering fee	6,634.53	
		72,979.84
Machinery foundations:		
Material	4,680.43	
Labor	3,890.16	
	8,570.59	
Engineering fee	857.06	
		9,427.65
Piping complete, by contract, including labor	15,654.76	
Engineering fee	1,565.47	
		17,220.23
Contingent costs	5,666.91	
Engineering fee	566.69	
		6,233.60
Grand total		$364,023.89
Of the above, the rotary converters, substation switchboard, substation cables, substation step-down transformers main-line step-up transformers, material and labor cost	38,500.00	
Engineering fee	3,850.00	
		42,350.00
Total cost of generating plant		$321,673.89

Complete operating-cost figures are not available, largely for the reason that accurate power measurements have not been made because the load is subject to such frequent and heavy fluctuations. Perhaps a fair indication of the fuel rate may be gained from the record of an output of 14,025 kilowatt-hours in 19½ hours from one unit. On a basis of 1000 kilowatts rating this is a load factor of 72 per cent. average, while on a rating of 1650 kilowatts, which is much nearer the customary rating of gas engines, the load factor would be only about 43½ per cent. The total coal consumption for this output, including that necessary to put the producer in the same condition as at starting and after cleaning the fires, was 27,672 pounds, or about 1.97 pounds per kilowatt-hour.

The coal burned during this run was Eagle River (W. Va.) bituminous, of which the following is a representative proximate analysis:

	Per Cent.
Fixed carbon	65.45
Volatile matter	30.05
Moisture	1.20
Ash	2.75
Sulphur	0.55
	100.00

This coal costs $3.40 per ton in cars delivered at the plant.

Considering the low rating given the engines and generators, the results are very creditable and the first cost moderate.

Elementary Lectures on the Gas Producer

By Cecil P. Poole

Specific Heat of Gases

This lecture is not going to be near so fascinating as a detective story—in fact, it may be rather dry reading in several places, but if you have any desire to become a competent gas-power engineer, you must know about the specific heat of gases and some other things that may seem at first uninteresting. Just as a minor instance, if you did not understand specific heat and its effects, you would not know why producer gas should leave the generator as cool as possible, and merely telling you that that is so would not make much impression on your memory. Then again, you would not be able to understand some things about generator temperatures that you simply must know in order to handle a producer plant intelligently. So here goes for specific heat first.

The specific heat of any substance—wood, coal, brick, water, air, gas or anything else, is the quantity of heat required to raise the temperature of *one pound* of that substance *one degree*, Fahrenheit. Gases, however, have two specific heats, according to whether they are allowed to expand when heated or are confined to a constant volume. That is, if the gas is in a closed vessel and heat is

applied to it, a certain quantity of heat will raise the temperature one degree, but if the gas is free to expand against the pressure of the surrounding atmosphere, more heat will be necessary to raise its temperature one degree, because the gas does work when it expands against the atmospheric pressure, whereas it does none when it is so enclosed that it cannot expand.

These two specific heats are called specific heat at constant volume and specific heat at constant pressure. When the term "specific heat" is used, without stating any quantity of gas, it is understood to refer to one pound. It is frequently convenient, however, to consider the heat required to raise the temperature of a given volume of gas or air, especially when it is confined so that it cannot expand, and when this is done, it is always stated as the specific heat *per cubic foot*, or whatever the unit of volume may be. For this reason Table 9, giving the standard specific heats by weight, has been extended to give the specific heats per cubic foot at constant pressure and constant volume. The weights per cubic foot are also given. All of the figures are based on a temperature of 32 degrees, which is the standard temperature for calculations of this sort, as explained last week.

TABLE 9. SPECIFIC HEATS AND WEIGHTS OF GASES.

	Specific Heat Per Pound.		Pounds Per Cubic Foot.*	Specific Heat Per Cubic Foot.*	
	Constant Pressure.	Constant Volume.		Constant Pressure.	Constant Volume.
Hydrogen	3.409	2.412	0.005589	0.01905	0.01348
Oxygen	0.2175	0.155	0.08921	0.01940	0.01383
Nitrogen	0.244	0.1727	0.07831	0.01911	0.01352
Air	0.2375	0.1685	0.08073	0.01917	0.0136
Steam	0.48†	0.36†	0.0502	0.0241	0.0181
Methane	0.593	0.4683	0.04464	0.02647	0.0209
Ethylene	0.404	0.333	0.07809	0.03155	0.026
Carbon monoxide	0.248	0.176	0.07831	0.01941	0.01378
Carbon dioxide	0.217	0.1535	0.1227	0.02663	0.01883

*Measured at 32 degrees and atmospheric pressure.
†At temperatures above 212 degrees and atmospheric pressure.

When a gas is heated, if it is free to expand against the pressure of the atmosphere, it will increase in volume; starting at the standard temperature of 32 degrees, the increase in volume is 0.00002035 per cent. for each degree by which its temperature is higher than 32 degrees; if it is confined so that it cannot expand, then its pressure will increase 0.00002035 per cent. with each degree of temperature increase above 32. This seems a small figure, but when the temperature runs up into hundreds and thousands of degrees, it counts up. For example, if the temperature be 1032 degrees, a cubic foot will increase to 3.035 cubic feet, if the gas is free to expand; if it is not free, the pressure will increase to 3.035 times the original pressure, which, of course, is by no means a negligible increase.

When the composite gas made by a producer issues from the generator at a high temperature, loss of heat energy is entailed as compared with the results obtained when the temperature of the delivered gas is lower, because, as just explained, heat units are used up in raising the temperature of gases, and the higher the temperature, the more heat is rendered useless for other purposes. For example, suppose a producer was delivering 10,000 cubic feet of gas an hour at a temperature of 1000 degrees, and the composition of the gas was as follows:

Carbon monoxide	22 per cent.
Hydrogen	13 per cent.
Methane	1 per cent.
Carbon dioxide	7 per cent.
Nitrogen	57 per cent.

The temperature of the gas would be 968 degrees higher than the standard temperature of 32 degrees, hence its volume would be $(1 + 968 \times 0.002035) =$ 2.97 times as great as it would be at 32; therefore, the volume at the standard temperature would be

$$10{,}000 \div 2.97 = 3367 \text{ cubic feet.}$$

Then the weights of the various gases, and their specific heats at constant pressure, would be as follows:

Carbon monoxide	741 cu.ft. × 0.07831 =	58.02 lbs.	Wgt. × 0.248 = 14.39 B.t.u.
Hydrogen	438 cu.ft. × 0.00559 =	2.45 lbs.	Wgt. × 3.409 = 8.35 B.t.u.
Methane	34 cu.ft. × 0.04464 =	1.52 lbs.	Wgt. × 0.593 = 0.90 B.t.u.
Carbon dioxide	236 cu.ft. × 0.1227 =	28.96 lbs.	Wgt. × 0.217 = 6.28 B.t.u.
Nitrogen	1918 cu.ft. × 0.07831 =	150.20 lbs.	Wgt. × 0.244 = 36.65 B.t.u.
Totals	3367 cu.ft. × 0.07162 =	241.15 lbs.	Wgt. × 0.2761 = 66.57 B.t.u.

The sum of the specific heats of the several gases is 66.57 and this means that for each degree of temperature to which the gases are heated, 66.57 B.t.u. are tied up. Consequently, if the same gases issued from the generator at 700 degrees instead of 1000, the gases would be heated to 300 degrees less temperature and there would be a saving of

$$66.57 \times 300 = 19{,}971 \text{ B.t.u.}$$

per hour. Now, 2545 B.t.u. per hour are the equivalent of one horsepower, so that the reduction of temperature would mean a saving of

$$\frac{19{,}971}{2{,}545} = 7.8 \text{ horsepower}$$

in the form of heat energy.

The foregoing example was worked through on the basis of the usual specific heats (per pound), but it could have been shortened considerably by using the volumetric specific heats at constant pressure in the fourth column of Table 9 instead of first calculating the weights of the constituent gases and then their specific heats, and the results would have been a trifle more accurate, theoretically. The accuracy, however, is not a consideration, because gas analyses and specific heats generally are open to suspicion beyond the third digit. Figuring in volumetric specific heats:

Carbon monoxide	741 cu.ft. × 0.01941 =	14.38
Hydrogen	438 cu.ft. × 0.01905 =	8.34
Methane	34 cu.ft. × 0.02647 =	0.90
Carbon dioxide	236 cu.ft. × 0.02663 =	6.28
Nitrogen	1918 cu.ft. × 0.01911 =	36.65
Specific heat of the producer gas		66.55 B.t.u.

The result, it will be noticed, is the specific heat of the 10,000 cubic feet of gas being considered, and, as just explained, it means that this number of heat units was used in raising the temperature of the total quantity each degree. Comparing the two methods of figuring again, the second method, dealing with volumetric specific heats, while requiring less calculation, is open to the objection that it does not give the specific heat of the gas per pound, while the first method gives the figures from which that can easily be determined. Thus, the weight was 241.15 pounds and the total specific heat 66.57 B.t.u.; the standard specific heat, therefore, is

$$\frac{66.57}{241.15} = 0.2761 \text{ B.t.u.}$$

As "specific heat" means heat per unit, it is evidently rather absurd to be talking of "total specific heat," meaning the heat required to raise the temperature of a given number of pounds or cubic feet one degree. The term "sensible heat" is in general use as meaning the quantity of heat that has been taken up by the gas or air in raising its temperature; this, however, does not mean the heat per degree of temperature increase, it means the total heat used in raising the temperature from the standard temperature of 32 degrees. What we are talking about, therefore, is the sensible heat per degree of temperature increase, which may be conveniently shortened to "sensible heat per degree." In the example that has just been given, the sensible heat per degree was 66.57 B.t.u. for the mass of gas considered; namely, 10,000 cubic feet.

To emphasize the distinction between the various kinds of heat that have been mentioned, perhaps a little list of definitions is advisable.

Specific heat: Heat units required to raise the temperature of one pound one degree.

Volumetric specific heat: Heat units required to raise the temperature of one cubic foot one degree.

Sensible heat: Heat units used in raising the temperature of a given weight from 32 degrees to the existing temperature.

Sensible heat per degree: Heat units required to raise the temperature of a given weight one degree.

Volumetric specific heat = Specific heat × weight per cubic foot.

Sensible heat per degree = Specific heat × weight of gas.

Sensible heat = Sensible heat per degree × temperature above 32 degrees.

Besides the disadvantage of wasting heat, as described, the delivery by a generator of gases at high temperatures entails the additional cost of excessive cooling in the scrubber. Of course, this is not so expensive a waste as that of carrying away a lot of heat that might be utilized in the generator, but it is a practical disadvantage. A further objection to high delivery temperatures, when bituminous coal is being gasified, is that more of the hydrocarbons are "broken up" into hydrogen and carbon dust, or lampblack, as explained in the last lecture, because high temperature in the issuing gas means that the top of the generator is hotter than necessary, and that is where lampblack is produced. The matter of generator temperatures, however, is sufficiently important to be given a whole lecture of its own, and that will be done the next time.

Joints and Gaskets on Gas Engine

By Frank E. Booth

The joint surfaces on the cylinder and cylinder head are usually machined with a rough thread-like finish to receive the gasket, which offers a much greater resistance to blowouts than was obtained with the old-time smooth surface.

The surfaces should not be too broad, as this distributes the pressure exerted by the studs over a large area, with a consequent reduction in pressure per square inch. On cylinders in which the head closes both the cylinder bore and the water-jacket space, trouble is sometimes caused by the packing giving way between the bore and the jacket, the water finding its way to the cylinder and interfering with operation. To obviate this difficulty some makers when facing the cylinder cover leave it a few thousandths higher on the part butting against the cylinder wall than on that next to the jacket wall.

When packing persists in giving out between two smooth surfaces, it is sometimes possible to get good results by chipping a groove around the end of the cylinder barrel, concentric with the bore. Ground joints for cylinder covers and valve cages give the least trouble.

On square or oblong surfaces, such as the packing surfaces of handhole plates on water jackets and inclosed crank cases, a thread-like finish is of no advantage unless it follows the contour of the plate; since this is not readily machined some makers cast the grooves in the plate and grind the surface straight. If the holes in the gasket have not enough clearance, the gasket will bunch up around the studs and prevent the cover from coming down solid.

If graphite be rubbed over the face of a gasket resting against the cylinder before the joint is closed, the head may be removed without breaking the packing. If the ordinary gasket cut from sheet asbestos be dipped in boiled oil before putting it in place it will give better results; the effect of the oil seems to be to toughen the asbestos. When a thick gasket refuses to hold between two smooth true surfaces an asbestos paper one will usually fill the bill.

When the packing gives out under the exhaust manifold on a multi-cylinder engine and the surfaces on the cylinders are found to be slightly out of line, use thick asbestos packing well soaked in water and pulled down solid while wet.

When pulling up the nuts on cylinder-head studs, go around the circle tightening each nut a little at a time, and after the engine has run for a short time, tighten the nuts again.

CORRESPONDENCE

The Armengaud Torpedo Turbine

With reference to F. R. Low's interesting notes in the issue of November 1 on the Armengaud gas turbines used for torpedoes, I presume that the power required to compress the air is included when reckoning the oil consumption per brake horsepower. If I am right, then one brake horsepower-hour is obtained at the expense of 0.9 pound of oil plus the energy in the compressed air. I would like it if Mr. Low would make this clear, because the success of this torpedo turbine is probably due to its utilization of previously compressed air. A gas turbine which had to compress its own air would be in a very different position.

R. M. Neilson.

Glasgow.

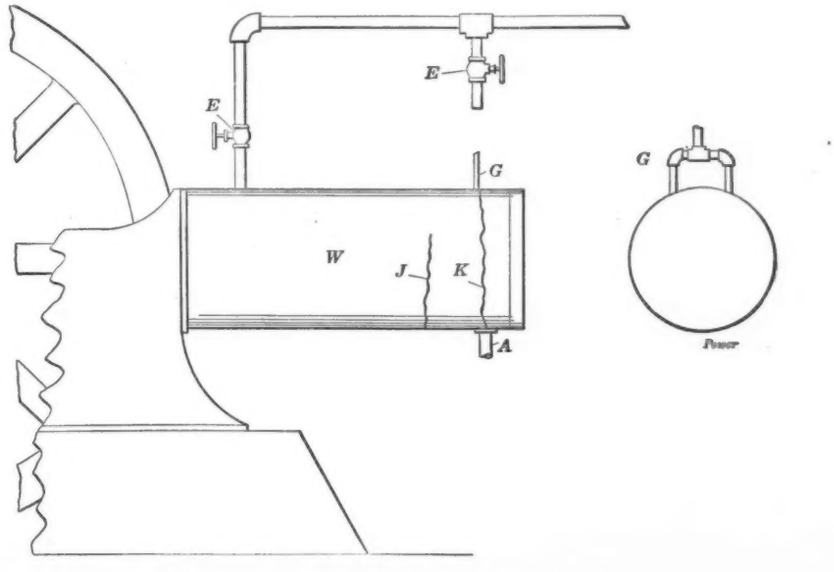
[The compressed air used by the turbine is previously compressed and stored in a tank in the torpedo hull. The fuel consumption stated probably does not cover the power expended in compressing the air; that is, the turbine uses 0.9 pound of oil plus the energy in the compressed air for each brake horsepower-hour developed.—Editor.]

Working with a Cracked Water Jacket

The accompanying sketch shows a gas-engine cylinder that was kept in commission after having two bad cracks *J* and *K* in the outer jacket wall; the crack *J* was on the outside of the water jacket and the larger crack was on the inside of the wall, starting at the top and running three-fourths around over the water inlet *A*. This crack *K* was about two inches from the end of the piston stroke and was patched with a plate, asbestos and cap screws, but the patch could not be made tight enough to stand the pressure of the water entering at *A*, and would leak enough to short-circuit and stop the engine. The water was then reversed and run in on top through the pipes *E*, *F* and *G*, and out at the bottom *A*. In this way the engine was kept cool and ran nicely for more than six months.

F. W. Sanders.

South Charleston, W. Va.



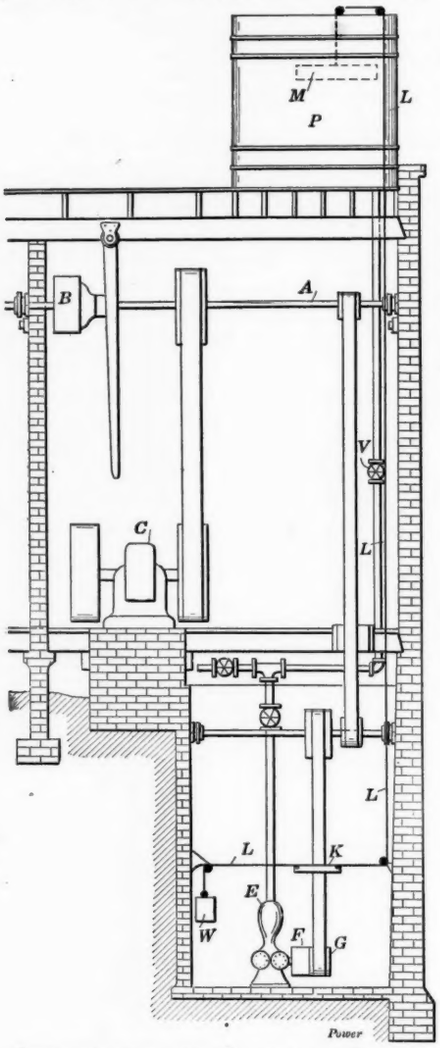
Working with a Cracked Water Jacket

Readers with Something to Say

Automatic Water Supply System

The accompanying sketch shows an automatic water-supply system for small manufacturing plants, similar to one I installed several months ago which is now in operation. This system can be installed at a very small cost, and will be found to be very economical.

In the elevation shown, *A* represents the main line shaft for operating the machinery of the factory; *B* a clutch for



ARRANGEMENT FOR AUTOMATIC CONTROL

throwing on and off the power; *C* a gas engine, or motor, belted to the shaft *A*; *E* a pump driven from the main shaft by means of belts and a jack shaft; *F* and *G* a loose and a fixed pulley; and *K* a belt shifter.

When the level of the water in tank *P* reaches the lower limit, the float *M*, through the cord *L*, pulls *K* over, thus shifting the belt onto the fixed pulley and putting the pump in operation. When the tank fills and the float reaches its upper limit, the counterweight *W* pulls *K* in the opposite direction and the belt is thrown back onto the loose pulley and the pump stops. Any desired water level may be maintained in the tank by adjusting the length of the cord.

The advantages obtained by the use of this system are even water pressure without pulsations, the possibility of increasing the pressure in case of fire by closing valve *V*, the possibility of having water when the pump is not running, and the elimination of the loss of power due to the pump working against a high friction head, which is the case when only a small amount of water is being used.

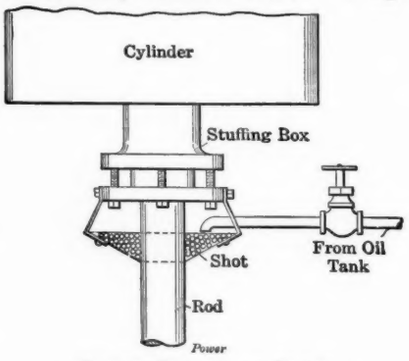
F. B. HAYS.

Indianapolis, Ind.

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words, wanted.

Oiling Vertical Piston Rods

The accompanying sketch shows a simple and effective device for oiling the piston rods of vertical engines. A cone-shaped pan, having a hole slightly larger than the rod to be lubricated, is attached by suitable lugs or straps to the stuffing box, or bottom of the cylinder. The pan is filled with buckshot, onto which oil is fed from any available source. A sight



OILING DEVICE IN PLACE

feed placed in the pipe adds to the convenience of the arrangement.

The upward and downward movement of the rod causes the shot to roll around against one another, distributing the oil and depositing it in a film on the surface of the rod.

C. J. LARSON.

Dubuque, Ia.

Why the Turbine Failed to Carry Its Load

A large cotton mill in the South was using what in that locality was called "second-class power." This is the term given to power that is sold at a cheap rate but its users are the first to suffer or be cut off in case of any disablement of the central station, which in this case was a hydroelectric plant.

The firm received notice that in twenty-four hours it would be cut off and that it would be obliged to wait at least two months before being supplied with any more power from the central station. Therefore it became necessary to put its own plant speedily into condition in an attempt to continue the operation of the factory.

The business had somewhat outgrown the plant, but the boilers were fired up and the plant started. The equipment consisted of two Babcock & Wilcox boilers and one steam turbine. As everything seemed all right, the turbine was brought up to sped and the load thrown on. After a few minutes, however, it began to slow down and every time the load was put on the turbine would stall. As the load was no heavier than had been carried previous to shutting down the plant, it seemed a puzzle why it would not again carry the same load. Therefore, an expert was sent for. After going carefully over the ground and finding nothing wrong with any part of the turbine, he went to the boiler room and immediately located the trouble. The boilers had been used for heating and to furnish steam for some other purposes but had not received much attention. Many of the tubes were almost completely closed with scale and it took a crew of men one week to clean those of one boiler, after which the load was easily carried.

EDWARD T. BINNS.

Philadelphia, Penn.

Trouble with a Vacuum Pump

Considerable difficulty was experienced with the vacuum pump on a condenser attached to a steam turbine. This pump was 12 and 36 by 18 inches and when starting up would run until a vacuum of about 20 inches was registered on the gage, after which it would gradually slow down and finally stop.

The piston was examined and found to be all right as was also the air cylinder. The decision arrived at was that the hot air from the condenser coming into the air cylinder expanded the piston, and the

cylinder, being cooled by cold water, did not expand, hence the piston fitted too snugly.

However, this pump took steam from the end of a steam line from which four large, heavily loaded engines also received their supply and it was found that these engines used steam so fast that the pump just managed to get enough to enable it to pull a 20-inch vacuum and then would stop.

A line direct from the boilers was put in and there has not been any trouble since.

C. A. HELMAN.

Philadelphia, Penn.

Introducing Solvents into Boilers

While looking over various issues of POWER, I noticed that the subject of scale in boilers is often referred to and different qualities of boiler solvents are discussed, but very little is said regarding the method of introducing them. Some engineers introduce the solvent when washing out their boilers by way of the manhole. Of course, in such a case no extra expense is involved; but, as a rule, the periods of washing out are so far apart that the use of the solvent at these times only amounts to very little, for, in the natural course of running, it will be blown out and lost long before the next charge can be introduced. If the boiler is put out of service as often as the solvent is to be introduced, an unnecessary expense is involved.

In my opinion it is much better to introduce the solvent in small quantities at short intervals than to put in a large quantity at once; also if the water is very bad, a much larger quantity could be introduced more systematically during a given length of time and with better results. For example, with some waters, a charge of 30 pounds of soda ash once a month might cause serious trouble for a while after it was put in, but six or seven pounds a week would not injuriously affect the working of a boiler; and, moreover, would be beneficial.

In my boiler room, I have a convenient but simple and inexpensive rig that works to perfection. On the suction side of the feed pump a tee is placed, one branch leading to the feed-water supply and the other running in the opposite direction and turning down toward the floor, a valve being installed in the horizontal pipe of both sections. When it is necessary to introduce a charge of solvent the pipe leading down to the floor is removed, the solvent is dissolved in a pail of water which is placed under the pump connection, the piece of pipe that was removed is replaced and by closing the valve on one branch and opening the other the solvent is drawn into the pump and forced into the boiler with very few strokes of the pump; then the valve may be closed and the pail removed until wanted again. The same attachment can be made to the suction of a power pump or to an injector. Of course, owing to difference in circumstances which would be found in different places, the details of the connection might vary somewhat, but the principle would remain the same and any ordinarily intelligent engineer should be able to rig it up without difficulty and at no particular expense other than that of a few fittings which are usually carried in stock.

CHARLES H. TAYLOR.

Bridgeport, Conn.

Old Boilers in Massachusetts

In spite of the fact that the authorities in Massachusetts for the past twenty years have endeavored to protect the public from the dangers arising from the operation of boilers of faulty construction, there are still a great many in service whose age alone would seem to be sufficient reason for their being condemned or should at least occasion investigation as to why, violating as they do many of the rules that are rigidly enforced in new installations, they are allowed to remain a menace to life and property.

In most laws enacted to protect the public, such as the enforced adoption of air brakes, car fenders, automatic couplers, etc., a certain time was allowed in which to comply with them, after which a penalty was imposed for noncompliance, and the result is that the public is receiving the benefits intended. The boiler rules of Massachusetts contain no such provision and so long as a boiler installed previous to May 1, 1908, remains on its setting, it may be subject to many violations of the rules that would not be allowed in a new installation or even when relocating the same boiler. It is strange logic which prohibits the construction of boilers over a certain diameter having the lap joints and allowing boilers having that type of joint to continue to become old and menace the public with whatever danger the law sought to avert.

An example of this can be found in an old boiler, possibly the oldest in service in Massachusetts, which is located in Lynn, and which, although patched and rusted and possessing many of the prescribed evils, is still doing duty in the service of a large corporation. From information obtained from an old employee, this boiler furnished steam to drive the old "America," a locomotive purchased in the late 60s by the Eastern railroad and gradually descended from the dignity of hauling the fast express trains to the locals, then to a switch engine and then to furnishing steam for heating cars in the storage yard.

The inspector's certificate furnishes the following data: Age, unknown; length, 16 feet; tensile strength, 45,000 pounds per square inch; thickness of shell plates, 3/8 inch; type of joint, single-riveted lap; strength of joint, 49 per cent.; type of boiler, locomotive; diameter of shell, 48 inches; thickness of head, 1/2 inch; pressure allowed, 52 pounds.

The Massachusetts boiler rules provide that for this type of boiler a factor of safety of 5 shall be used in determining the safe working pressure. Using the formula

$$\frac{\left(\begin{array}{c}\text{Tensile strength} \times \text{thickness} \\ \text{of sheet} \times \text{strength of joint,} \\ \text{per cent.}\end{array}\right)}{\text{Radius} \times \text{factor of safety}} = \left\{\begin{array}{l}\text{safe working} \\ \text{pressure,}\end{array}\right.$$

if the boiler were new a pressure of 68.8 pounds would be allowed, or 16.8 pounds more than is allowed after the boiler has been in service forty years.

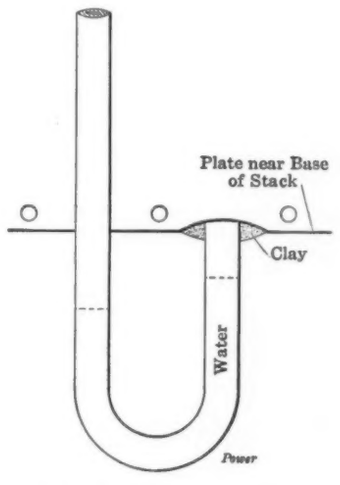
It would be interesting and possibly occasion some action in the matter if some of the readers of POWER would send in data and information concerning other old boilers, as it may be that I am wrong in assuming that this is the oldest boiler doing high-pressure service in this State.

CHARLES F. ADAMS.

Lynn, Mass.

A Homemade Draft Gage

The accompanying sketch shows how a practical engineer determined his stack draft without any expense. He took an ordinary water-gage glass and by heating it at the center bent it into the form illustrated. With a drift pin and hammer he then made a hole between the plates near the base of the stack. The glass was held in an inverted position and the U filled with water to the depth of a couple of inches. One leg was then inserted into the hole made by the drift pin



GAGE INSERTED IN STACK

and the space around the tube was filled in with clay to make it air tight. The readings obtained were plain and accurate enough for ordinary calculations.

EDWARD T. BINNS.

Philadelphia, Penn.

Handling Men

Doubtless the most intricate factor in any manufacturing establishment is the human element. The relation of the different departments to one another, and of those in authority to their subordinates, has a far more vital bearing upon the economical operation of a plant than the performance of any mechanical apparatus in the department. Yet in most cases manufacturers leave the problems of labor and wages to work out their own salvation.

All costs of operation and production have been figured to a nicety, but when it comes to the management of men, and their scale of wages, the much needed system is often thrown aside, and the problem left unsolved from year to year; and always at an enormous cost to the company, as well as dissatisfaction among the employees. The frictional losses in the human machine are far in excess of those in a piece of mechanical apparatus.

Many times the chief engineer, by making small adjustments among the men, can produce large savings to the company when not nearly so much would be realized from weeks spent in the most careful adjustments of the various mechanical losses. I do not, in any way, wish to discredit the value of mechanical efficiency, or any of the many other things which fall to the lot of the painstaking engineer. But the chief should have perfect control of not only the mechanical element but the human element as well. He should be a man of character and strength, combined with kindness and good wishes for his men. He must be a man among men; a human force; a leader, not a driver; he should be to the human machine what the governor is to an engine; always keeping in touch with those under him and always ready to discuss any differences which may arise, giving credit to whom it belongs, and favor to none. Nothing will foster discontent, and throw the whole force into confusion, sooner than favoritism, harshness or injustice upon the part of those in authority.

The chief who tries to carry himself far above those whom he directs, forgetting that he, too, was once a subordinate striving for advancement, will soon find that his department is in need of better leadership.

The feelings the men have toward the firm are governed almost entirely by their feelings toward the man who directs them from day to day. The chief, as well as the head of the firm, must remember that the men have rights which must be recognized. The recognition of these rights, and the proper remuneration for their services, is the lubrication which keeps down the frictional losses in the human machine.

No work calls for more tactful attention than that of handling men. If the best services are to be obtained, the chief should have full authority to settle all questions which may arise in his department. He should be a man who appreciates effort on the part of his assistants, and he should discuss all topics with his subordinates which have anything to do with their welfare.

Efforts should be made to interest the men in economical methods of operation. One method which seems to give very satisfactory results to all concerned, is the inauguration of some well devised system by which the employer's gain is the employees' gain. This leads the men to feel that they are a part of the company, instead of just a cog in the wheel. In reality they are a part of the company, and should be recognized as such, for how long could any firm exist without the services of its employees? Give a man fair treatment together with what he earns, and a harmonious operation of all departments will be the satisfactory returns for the money invested.

J. M. Row.

Fort Flagler, Wash.

Pipe Vibrations

We were troubled for a long time by the vibration of our main steam header, a 14-inch extra-heavy pipe, about 45 feet in length. This shook so that the engineer had to run up the iron ladder and drive in wedges between the pipe and the wall.

It was finally decided that the vibrations of the pipe were in phase with some of the heavy reciprocating parts of the engines. To stop the vibrations, four heavy cast-iron weights were hung beside the pipe, these being suspended from the steel I-beam which formed the track for the traveling crane. These weights were then bolted to the pipe, the flanges being used as convenient points to which to bolt heavy iron straps which, in turn, were bolted to the weights. The weights stopped the vibration.

H. W. RANDALL.

Saginaw, Mich.

Uneconomical Operation of a Blower

Often when an engineer takes charge of a plant which has been in operation for some time, and in which changes and so called improvements have taken place, he finds auxiliary apparatus which is unsuitable for the purposes intended. Sometimes it is too large and other times too small; and particularly in the former instance, it is often difficult to convince the management that such is the case. Of course, it is better to err in having a piece of apparatus too large than in having it too small, but there should be some limit to size if economy is to be obtained.

A case of this kind came under my observation some time ago in which a horizontal balanced slide-valve engine, without any governor or regulator, was direct connected to a blower used for forced draft in the boiler plant. Owing to conditions existing at the plant, the steam pressure varied considerably and the fireman was accustomed to speed up the blower when the steam pressure dropped, regardless of the cause of the drop. By the time the pressure was considerably below normal the throttle would be nearly wide open.

When the load on the main engine was reduced or the normal steam pressure was restored through other means, the fireman was usually too busy with the fires and the water level in the boilers to look after the blower, with the result that occasionally the peripheral speed of the blower was sufficiently high to detach a blade, or damage the valve gear of the engine.

While, to a certain extent, the damage was the fault of the fireman, there were conditions over which he had no control, conditions which should have been made and kept right by someone higher up. In fact, the engine was three times as large as was necessary and this was primarily the cause of all the trouble. The fireman, knowing how hard it was to recover lost steam, usually speeded up the blower at the slightest drop in pressure, and instead of the pressure rising it often continued downward owing to holes being blown in the fires by the strong draft employed. Speeding the blower was the result of the fireman's education in that plant and he could not figure it out any other way but to do so when the steam pressure went down.

Some time after making the changes referred to, it was decided to rebore the cylinder of this engine and reduce its area by about 25 per cent. This was accomplished by inserting a liner and making a suitable piston, which was of the plug type, that is, one containing no packing rings. This change worked out satisfactorily in every respect.

About the same time, a throttling governor was also installed and set for a fixed maximum speed of about one-half that at which the engine had run previously. This eliminated most, if not all, of the troubles caused by excessive speed. It probably would have been impossible to reduce the speed by such an amount had other existing conditions continued, but changes were made in the operating force and the methods of operation and greater economy was attained.

In order to make the blower automatic, an ordinary stack-damper regulator was installed and connected to a cutoff valve in the steam pipe, which partially shut off steam when the boiler gages showed a certain predetermined pressure, never stopping the engine entirely, even though the pressure was near the blowing-off point, at which time it was running too slow to create much draft.

W. E. RECTOR.

Brooklyn, N. Y.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues.

Rope Drives

I noticed in the October 25 issue an answer to my letter in the September 13 issue, referring to the design of rope drives.

The question of what speeds at which it is advisable to run cotton or manila ropes depends very largely upon the condition under which the drive is installed. There is no question but that centrifugal force has a great deal to do with the effective result upon a pulley or wheel using either belt or manila rope or any other material that is practically incompressible, and having a comparatively small friction coefficient. So soon, however, as the material is capable of being wedged into place, centrifugal force is, to a large extent, neutralized; and this is the condition which exists with cotton rope. Anyone who has watched a cotton-rope drive and a manila-rope drive will be struck by the difference in the way in which the ropes leave the pulley. There is a decided tendency of the cotton rope to continue in the groove, which does not exist with the manila.

A belt or manila rope depends entirely upon the friction due to the weight or pull of the rope or belt on the pulley or in the groove, and neither wedges into place.

The effect of centrifugal force even upon a belt or manila rope may be considerably neutralized on long centers by the weight of the belt or rope; but on short centers it has to be neutralized, if at all, by excessive tension on both sides of the drive. On the other hand, with cotton rope with more or less possibility of wedge, the necessary weight or pull may be considerably diminished; and the action of centrifugal force is somewhat neutralized by the wedging action, so that on long drives or short drives through the action of the weight or rope tension in addition to the wedging action of the rope in the groove, the cotton rope is much more effective on high speeds, and due to the wedging action the theoretical and practical values of the rope drive very nearly coincide, neglecting the action of centrifugal force; that is, manila rope acts almost exactly according to theory, whereas cotton rope does not.

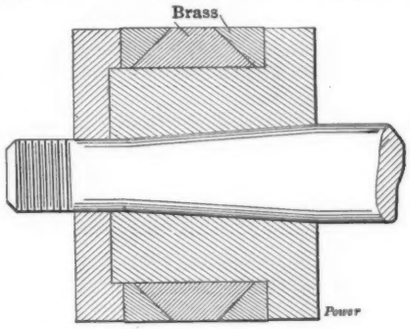
I quite agree with Mr. Davies that it is advisable to give full weight to the opinions of any eminent authority; but where a man has in his experience succeeded in getting certain results which are directly according to theoretical results, leaving out centrifugal force, it would seem advisable also to defer, not slightly but considerably, to his opinions. That is, it would seem to indicate that cotton rope can successfully be operated according to the theoretical value per rope at speeds up to 7000 feet per minute; whereas, on the other hand, it is found by practice that the limiting speed of manila rope is approximately 4800 feet per minute, which agrees very closely with the theory, taking into account centrifugal force.

HENRY D. JACKSON.

Boston, Mass.

Valves and Packing to Withstand Acid

In the issue of October 18, Frank Demarle asks about reliable packing and valves to use in an acid pump. I presume Mr. Demarle is using plunger pumps. In such a case the remedy is to use brass packing. The accompanying figure is self-explanatory. It should be noted that care must be taken about adjusting the nuts on the follower plate to prevent binding. When tightening the follower plate the outside rings are forced outward toward the cylinder. The two outside rings are split through with a thin hacksaw blade while the central ring is solid. All three rings must be bored to a neat fit on the plunger. This style of packing will be found to be decidedly better than flax.



BRASS PACKING FOR ACID PUMP

Regarding valves, use flat disks of brass having central pins to seat them true. Instead of only one week's service, Mr. Demarle will secure over a year's service, which will more than pay for the slight changes necessary to the plunger.

GEORGE H. HANDLEY.

Newburgh, N. Y.

License Laws

The letters on the subject of license laws and particularly those by J. J. Nigh are of much interest and they have led to some interesting and entertaining discussion in the columns of POWER. Without wishing to enter an argument on the merits of license laws, I would like to see some discussion on the question, "Should engineers defray the cost of bringing about license legislation?" A lecturer on license laws informed his hearers recently that rag pickers, swill gatherers, barbers, druggists, doctors and the members of a host of other vocations were licensed, and that it was for the good of the community that they were. Did all of these good people spend their time and money to bring about the enactment of laws which put a tax upon their pockets?

FRANK H. WILLIAMS.

New Haven, Conn.

From time to time articles have appeared in POWER for or against license laws, but none of them, in my opinion, hits the right spot. Our own law is a striking example of how license laws should not be used.

In 1892, I was appointed a committee of one by Queen City No. 1, National Association of Stationary Engineers, to try to get the city council to enact an ordinance to license engineers. Owing to the active and powerful influence of the plant owners, I was unsuccessful for three years in spite of the fact that I devoted all of my time and considerable effort and money to the purpose. In 1895 our city charter was revised and, having several warm personal friends on the revision committee, I succeeded in getting a license-law provision into the charter.

When it came to the appointment of an examining board, two obscure hardware dealers and a janitor were appointed to license the engineers. Again I was beaten and the law was dormant until 1900, when a fatal explosion occurred in which two men were killed. Then a demand for the enforcement of the law was made and three competent examiners were appointed. But, as soon as the scare had worn off a little, the personnel of the board was changed again and anyone who had the necessary $2 could get a license, whether he knew anything or not. I have actually seen Japanese that could not speak a word of English, possessing a license. I have seen men with licenses covering almost any plant in town come to work in a plant and ask the man there, upon being shown the feed pump, "Where does the steam go

into this pump?" One man with the same grade of license came into my engine room and seeing me using graphite for some pipe work wanted to know what it was and where it could be bought.

The consequence of all this is that we have had more explosions since the license law was passed than we have ever had. I wish that I had never bothered my head about license laws. I would be hundreds of dollars and a good deal of time ahead, not to say anything of the worry and effort.

F. E. ALBRECHT.

Seattle, Wash.

Quarter Turn Drive

In the November 1 issue of POWER, Mr. Bitterlich makes inquiry as to the design of quarter-turn drives for leather belts.

As a great many rules of various kinds have been proposed for determining the power of a belt, some varying from others by several hundred per cent., it is impossible to give any hard and fast rule that may be relied upon for ordinary straight drives. And, when the proper design of quarter-turn drives is desired, still less definite information is available and the best that is possible is a set of general rules.

The one basic principle in such drives, and which when once understood enables any drive to be designed properly, is that the center of one pulley must be in the same plane as the face of the other pulley. From this rule it will be seen that a belt after leaving one pulley must be delivered in line with the pulley it is running toward. The belt may be drawn sideways out of the plane of the pulley it is leaving, but it must always be delivered in the same plane as the face of the pulley it is running toward or else it will run off that pulley. It is thus evident that this drive will not run backward, and that if reversed the belt will leave the pulleys.

When a belt is pulled sideways, as is the case in this form of drive, the edge of the belt toward which the sideways displacement takes place tends to bulge out owing to the lateral stiffness of the belt and is no longer in close contact with the pulley. This action will decrease the contact and hence the driving power of the belt. To overcome this defect the angle at which the belt is drawn off should be kept as small as possible; also, in figuring the power of the belt a larger belt should be chosen than would be required for a straight drive transmitting the same amount of power. For greatest efficiency the drive should have the distance between shafts large compared with the diameters of the pulleys. Also, a wide belt should not be used.

Applying the above to Mr. Bitterlich's particular problem I should say that his drive would undoubtedly work, only the driving power would not be very large and could be materially improved by placing the pulleys further apart and using a 4-inch double belt, as suggested by the master mechanic, instead of the 6-inch single belt.

The speed of 1600 feet per minute is certainly on the safe side if the required amount of power can be supplied with that speed, but the speed should not much exceed 2000 to 2500 feet in order to avoid undesirable strains in the belt due to the change in lateral curvature where the belt is drawn off.

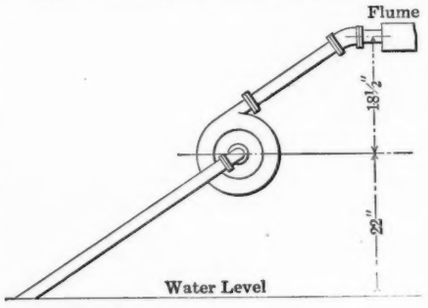
W. L. DURAND.

Washington, D. C.

Irrigation Problem

In regard to the irrigation problem in the October 18, the proper way in which to put in the piping is shown in the accompanying figure. With this layout the friction in 55 feet of pipe, three 45-degree elbows and one 90-degree elbow is saved.

Approximately, each 45-degree elbow



IMPROVED ARRANGEMENT OF PUMP AND PIPING

equals a foot of head and the 90-degree elbow 4 feet of head, thus making in all 7 feet. The one 30-degree elbow would add about a foot, so the net saving would be 6 feet of frictional head, and with 0.4 of a foot for the pipe, the net saving would be about 40 horsepower.

WILLIAM O. WEBBER.

Boston, Mass.

Central Station vs. Isolated Plant

It is a fact that some classes of engineers are being slowly but surely pushed out of existence by the large heat and power companies. You say that the agent of the company makes a flattering proposition, shows figures as to what it costs now to keep an engineer and other help in the isolated plant, how heat and power can be furnished without dirt, ashes to be removed, how the basement can be used for other than engine-room purposes and how the smoke nuisance can be eliminated. I could mention a hundred or more reasons why the central-station agent gets the willing ear of the owner or manager, and as sure as the sun will rise, the very existence of all of us will ere long be threatened. Now, what are we going to do about it? Shall we do as is usually recommended, get indicators, hot-water meters, calorimeters, etc., make thorough evaporation tests of the boilers, show the heat value of the fuel, the percentage of ash, the temperature of the flue gases, etc., which really is the only correct way in which to ascertain the cost of operating a plant? But who can afford to do this at salaries which are now paid in just such places where the danger of being pushed out is the greatest, where engineers get from $2.50 to $4 per day? The owner of the plant would not buy these instruments and the engineer cannot save enough from his earnings; so you see it is much easier to recommend than it is for the engineer to follow.

I want to suggest a way in which the cost can be approximately ascertained without the use of the proper instruments. The owner pays all the bills and that is the basis on which he forms his conclusions. The engineer should start by seeing that he gets a ton of coal weighing 2000 pounds. Start on that ton, have no other fuel, burn up that ton of coal and wheel out the ashes, weigh and record the amount, the date, the name of the coal dealer and the quality of the coal; then, keep a record of the load; if electrical, the ammeter tells; if heating, figure the total cubical contents of the rooms; if refrigerating, the procedure is the same; then, keep a record of the wages and labor cost, the lubricating cost, the supplies and repairs.

When the agent makes his "spiel" after he has carefully scrutinized all the bills, he uses his most expressive statement, "And last but not least, Mr. Owner, taxes, depreciation and insurance," he will wave his hand like a magician and say, "we do not even count them, just your own figures for actual expense." He quickly ascertains the average load and divides it by the cost, and here you are, so much per kilowatt-hour. Then it is up to the engineer to have his say, which should be something like the following:

"Now, Mr. Owner, allow me to show you why the power cost is so high and how it can be reduced lower than the agent's figures. First of all, the boilers are not clean enough. Then, I find that the coal you bought from so and so gave better results than the coal you bought from the other concern. If you will buy a good boiler compound to keep my boilers perfectly clean, I will reduce the coal bill all the way from 10 to 25 per cent. Then, I will save 20 per cent. more if I get that good coal, making a total saving of 45 per cent. Let us figure on last month's expense for the power plant at 45 per cent. saving and you will see that we can produce the power cheap enough. Then, if you will give me $5 per month more, and that is little enough, I will use it to buy a steam-engine indicator so that I can indicate my engine."

You may see a change in the owner's color, but do not be afraid; he will not faint, so continue:

"Then, I would like you to buy a thermometer to screw into the boiler-feed pipe so that I can keep a record of the temperature of the boiler feed; the water should be nearly 212 degrees Fahrenheit; every eleven degrees added to the water means 1 per cent. saving. I will also ask you to get a thermometer to put in the breeching, so that I can measure the flue-gas temperature, as I want the gases to escape at as low a temperature as the draft will stand, about 500 degrees. I will make a draft gage to see if there is sufficient draft to burn the coal economically, say not less than ¾ inch. Really, Mr. Owner, if you take a little more interest in me and the plant it will be money in your pocket, and the agent's second visit will not last five minutes. But should he come again and you still entertain any of his various propositions, let him make a test of all the plant, tell him you do not want him to guess about it; you want to know what each department will cost; you want him to show you how much water is evaporated; have your engines indicated and have all this done under the supervision of your trusted consulting engineer."

The owner will then begin to realize that he has a man in the engine room who represents him; who will always look out for his interests; who will, if given half a chance, make dollars for him.

WILLIAM NOTTBERG.

Kansas City, Mo.

Trouble with Metallic Packing

In the issue of November 1, we notice a letter on page 1944 headed "Trouble with Metallic packing," in which it is said that a 100-horsepower engine was packed with metallic packing over one year ago. The writer states that the packing was composed of soft metal in small grains containing considerable graphite. The packing, being in cotton tubes, was placed in the stuffing box with a copper wire around the piston rod inserted before the packing, and a ring of fiber packing on top.

We manufacture a packing which in some ways corresponds with that described by Mr. Chapman.

We write this, not to criticize him, but in hope of enlightening him and other readers of POWER on the use of plastic metallic packing, which we have been manufacturing for many years.

Mr. Chapman states that the packing gave no trouble all last year, and that the engine ran nicely. But, after being idle for about three months and started again, the packing began to leak, and then the gland was tightened only slightly, which partially stopped the leak, and, having no more of the packing on hand, the engine was allowed to run with the small leak.

If there had been more of the packing on hand to add to the old and properly fill the stuffing box, the leak could no doubt have been stopped at once. The fact that the packing did not leak during the first year or more would indicate that it was compressed into a steam-tight joint, although it was probably not thoroughly compressed but in more or less of a honeycombed condition, and the action of the hot piston rod gradually compressed the packing, until it became loose in the stuffing box, causing the leak and allowing the copper-wire bushing to become dislodged, leaving an opening around the piston rod through which the packing could be drawn into the cylinder.

This packing should be thoroughly compressed in the stuffing box, by keeping the gland snug against the packing, following it up frequently for the first hour or two. After the packing is properly compressed, the ordinary pressure of gland is sufficient, and the packing will last indefinitely without renewal or special attention. If the packing had been thus compressed, the leaking would have been avoided and the copper-wire bushing would have been held in place, preventing the packing from being drawn into the cylinder.

In using this class of packing it is very necessary to have a sufficient quantity on hand to properly fill the stuffing box, allowing for about one-third compression of the packing.

The packing should be composed of an alloy of antifriction metals, just soft enough so that it cannot injure the piston rod, and just hard enough for durability. The metal should be thoroughly mixed with the best of graphite and other lubricating materials, so that they will remain permanently in the packing. It will be seen that this packing could not possibly heat or injure any piston rod by the pressure of the gland.

When the piston rod has passed through the plastic metallic packing, the packing must necessarily fit the rod exactly, without binding, its form remaining permanent, making a packing that is self-lubricating and practically frictionless.

When the packing wears so as to leak, more of the same packing may be added, and the leak will stop.

STEEL MILL PACKING COMPANY.

Detroit, Mich.

Metal for Cylinders

This important and interesting subject treated in the November 1 issue by Mr. Rector is one of the subjects much overlooked by the engine-room man, although the chemical make-up of the iron of the cylinders is a little out of the ordinary line for the engine room. Those who work in the engine room often have the chance to notice the difference in the wearing quality of an engine cylinder.

I recall sending out some men to bore a 20x48-inch Corliss engine cylinder. The cylinder was one composed of soft open-grain iron. A piston and new rings were fitted to the cylinder and the engine was started. The following day I was called by telephone, and notified that the cylinder was badly cut. Upon investigation I found that it was so badly scored that a light cut had to be run through the cylinder. A new head was made as well as new rings. The first head was made of iron which was too open and soft, it seemed to stick and cut. The second head was made of an iron having a closer grain.

I have found that a cylinder and rings should not be of like composition. The close-grain cylinder is more easily handled after getting started, while a soft, open-grain cylinder high in carbon will start off better. Mr. Rector asked about the steel-mixture cylinder. The use of steel scrap in the making of engine cylinders is very common. When this is done an iron much like charcoal iron is secured; however, much depends upon the skill used in the process. The so called semi-steel cylinder is a misnomer. Many people are still using such names when they know that it is not right. "Semi-steel," "ferro steel" and such like are all misleading names. When an engine cylinder is made by using steel in the melting furnace, the result is a reduction in the total carbon that the iron carries resulting in a close-grain iron. With a dense iron, of course, strength will follow density when the other metaloids are right. A low-carbon iron, such as produced by using steel punchings in the furnace, will make an excellent cylinder; in fact, cylinders for some of the most difficult duties are made in this way.

"Iron is iron" so long as it is suitable for the purpose for which it is intended and is of the proper composition. There is no difference between charcoal iron and coke iron so long as the analyses are the same. Charcoal irons generally are low in sulphur, a constituent that is hard to handle but somewhat under control in mixing steel with iron so long as a hot furnace is employed.

An iron low in manganese is not as suitable for a cylinder as one high in manganese, for manganese is a great strengthener when properly used.

For cylinders or castings needing a close texture, as in the case of steam cylinders, gas-engine cylinders, hydraulic cylinders, the following composition is suggested:

	Minimum. Per Cent.	Maximum. Per Cent.
Silicon	1.25	1.60
Sulphur	0.05	0.09
Phosphorus	0.40	0.55
Manganese	0.25	0.55
Combined carbon	0.75	1.50
Graphitic carbon	2.00	2.25

It is quite correct not to make bull rings and cylinders of the same composi-

tion. A good composition for the bull rings is:

Silicon from 2.25 to 2.60,
Sulphur from 0.10 to 0.13,
Phosphorus from 0.30 to 0.40,
Manganese 0.55.

This will make a good ring. The sulphur has a hardening effect but not enough to overcome the effect of the silicon which will make a soft but close grain; and this is what is wanted. Very true, many rings have worn out too soon because they were not made of the right iron.

The bull and snap rings should be soft as it is better for them to do the wearing and not the cylinder, for they can be renewed more easily than the cylinder. More care is needed in the selection of rings for high-pressure and high-speed work than for low pressure and low speed.

The composition of cylinders is quite an interesting subject for engineers, for it enables them to discover the causes of defects and to apply intelligent remedies.

C. R. McGAHEY.

Lynchburg, Va.

Common Sense

The principle of common sense, reasoned by POWER in the first-page editorial of the October 18 issue, is one of too great import to pass unnoticed; it is the nucleus of worth, of a man's earning ability. Real common sense is symbolical of efficiency, and one is never present without the other. This principle appears in three degrees, near common sense, common sense, supernal common sense; they are seen in the majority, in the many, and in the few. It is the instinct of human nature to feel that one possesses common sense; but will logical reasoning admit of this? Do one's daily actions prove it? Narrow-mindedness, pedantry, sluggishness, prejudice, lack of rational argument, never indicate common sense; these are the direct means of decreasing a man's worth to himself or to his employer.

The ability to reason correctly, to do the right thing at the right time, to use considerate judgment, to prove results, to show efficiency—these are the attributes of business common sense; they signify merit, elimination of waste, working with intent of purpose, working for the company's interest. The efficient organization head displays common sense in choosing an efficient superintendent, the efficient superintendent by surrounding himself with efficient foremen, efficient foremen by having efficient subordinates, and the latter by efficient practice. Such a combination is born of common sense, else it would not be effective.

A display of common sense cannot help but mold progress. Application to duty, right principles, mind training, advancing abreast of the age, these precede a greater field for talents, business prosperity and greater earning powers.

L. R. W. ALLISON.

Los Angeles, Cal.

Installing Globe Valves

In the November 8 number there is a letter by James Johnson on "Installing Globe Valves."

According to my experience he did not use very good judgment in removing one of the valves in the blowoff line, although he says that he has had very little trouble since. We have tried single valves on the blowoff lines and always have had trouble from leakage.

For the last twelve years or more we have had two valves on every blowoff and have had no trouble from leakage, renewing the disks of the globe valves once each year. On two of our boilers we have asbestos-packed cocks next to the boiler, and angle globe valves beyond the cocks, which are opened first and closed last, using the cocks for blowing off.

On the remainder of the boilers we have angle globe valves next to the boilers and gate valves beyond. The outside valve will hold whatever water leaks past the first valve, and in case the thread should strip on the valve stem of the first valve, the second can be used until the boiler can be spared to put in a new valve, which is important in our case as it is almost impossible to cut out a boiler for about seven months in the winter. Some engineer who reads this may say, "How about cleaning the boilers?" We clean our boilers but once a year and the inspector says that they are in fine shape.

W. O. PERKINS.

Bristol, Conn.

Diagrams for Criticism

In regard to the diagrams for criticism in the November 1 issue, Mr. Fryant has failed to give all the details of the conditions under which the diagrams were taken; hence I am compelled to offer several reasons for the jagged expansion lines. The type of engine, the steam pressure and the scale of the indicator spring should be given when a question of this nature is asked.

There may not be sufficient tension in the indicator cord on the reducing motion or wheel.

The operator might have failed to blow steam through his indicator two or three revolutions before taking the diagram.

There might have been water in the cylinder of the engine.

There might be lost motion in the engine or the reducing motion of the indicator.

I am under the impression that the jagged expansion is due to the spring in the indicator being too light for the steam pressure at the time the diagram was taken.

J. E. STROTHER.

Yuma, Ariz.

In the issue of November 1, I saw some diagrams which were submitted for criticism by H. J. Fryant. If he will relieve some of the cushion in the dashpots, he will find that the jagged expansion lines will disappear. I had a similar experience with a 14x36-inch Corliss engine running at 72 revolutions per minute. I attribute the trouble to the cushion causing the dash rods to bound high enough to cause a partial opening of the admission valves and I found that on relieving some of the cushion I had a smooth expansion line. However, I would like to hear from other engineers on this point.

G. E. GOODWIN.

Burlington, Ia.

What Causes the Engine to Run?

In the November 1 number, E. R. Teer tells how his engine continues to run when the bleeder to the steam pipe is open. I should say that the two drain valves on the cylinder must be open also and that the pipe going into the exhaust is smaller than the bleeder, or that it is stopped up a little to cause the steam to go into the cylinder through the drain valves and start the engine. This is the way in which I have a 10x14-inch engine connected, only I have a valve on the exhaust leg of the bleeder which I close. This is an easy way of starting the engine, for when the steam enters the cylinder the valves work so that the pressure is always on the piston in the way the engine is set to run. I use ¼-inch pipe all round.

D. F. CROWTHER.

East Boston, Mass.

Experience of an Indicator Man

I would like to make some comments on the article in the November 15 issue entitled "Experiences of an Indicator Man." I judge the engine was a Corliss and that the cutoff rods to the steam-valve hooks had been shifted.

Now, when the engine laid down with the load the regulator would drop and if the cutoff was equal, both steam valves would stop cutting off at once, but if they were unequal one hook would hold on and the other would unhook, thus making the mean effective pressure very unequal in the two ends of the cylinder. But, at the same time, the dashpots on this type of engine are always very noticeable and it seems to me that even a novice would see where the trouble was without applying an indicator.

W. E. HOPKINS.

Torrington, Conn.

Conducting a Steam Boiler Test

By H. S. Flynt

Points to be observed and the apparatus required are enumerated. A system of weighing the water is described and it is then shown how a test should be figured.

A boiler test is not a difficult undertaking, providing care is exercised in the arrangement of the simple preliminaries and the taking of accurate notes throughout the test. In conducting a test the following arrangements must be made, and apparatus obtained for making a simple evaporative test.

Weighing the Water

The blowoff cock of the boiler must be examined, and if the slighest suspicion of a leak exists it must be blanked off during the test. If a hot-water meter, newly tested and calibrated, is available it may be connected in the feed line between the feed water heater and the boiler and used to meter the water. As this apparatus is rarely kept on hand, except in the very large plants, the common and safe method of weighing the water in barrels is recommended. Three barrels are generally used, two being fitted with an overflow outlet close to the top, and a discharge pipe close to the bottom of each. They are carefully weighed on platform scales when filled with water up to the overflow pipe, and again when only filled with water up to the point level with the discharge pipe at the bottom of each barrel.

The barrels are then numbered and the calibration of each is noted in pounds. These two barrels are then placed upon a staging at a convenient hight for filling and discharging into the third barrel located below, from which the boiler-feed pump draws its supply. Each time a barrel is emptied into the lower barrel the measure of water should be marked with chalk upon the side of the barrel when its contents have been discharged, and always in this order; otherwise confusion in the count will result before the end of the test.

Apparatus Required

A reliable thermometer should be kept submerged in the reservoir barrel for taking the temperature of the feed water, while a reliable platform scale is required for weighing the fuel, the weight of the barrow or other holder being noted, and a uniform quantity of fuel weighed out each time and dumped on the floor as needed. A reliable thermometer, graduated to not less than 700 degrees Fahrenheit should be inserted through a hole in the uptake at some point close to where the gases leave the heating surface of the boiler. This thermometer may be removed from time to time, and a small iron pipe inserted, to which a water draft gage is attached by rubber tubing, for ascertaining the draft or "pull" of the chimney. This observation should be taken with the damper full open, half open and closed, and before and after fire cleanings.

Immediately before starting the test a piece of string should be tied round the gage glass at the hight of the water, and whatever the variation may be throughout the test, the water must be brought back to this mark as the test ends, which should not be of less than eight hours' duration, and should start and end directly after the fire has been cleaned. During the test 10 pounds of the fuel should be gathered from different parts of the heap and weighed carefully on a scale sensitive to one-half ounce, and then spread out on an iron plate on the top of the boiler setting for a few hours to dry. It is absolutely necessary to consider the performance of the boiler in comparative tests from the dry-coal basis, and by this means the approximate percentage of moisture in the fuel may be readily calculated. The ashes made during the test must be collected as carefully as possible without wetting, and from their total weight in relation to the total dry coal, the approximate percentage of incombustible matter in the fuel is determined.

What to Observe

Throughout the test the following observations should be made and noted on the record sheet every fifteen minutes:

Weights of coal and water, feed-water temperature, steam pressure and temperature of the escaping flue gases. At the close of the test, the figures under each heading are totaled and divided by the appropriate number of observations made for an average. From these averages the performance of the boiler, according to the standard conditions established by the A. S. M. E., may be calculated by aid of the steam and water tables. But the evaporation under actual conditions is merely a matter of simple division between the total water and total coal.

Figuring a Test

Assuming that the test has been with a 100-horsepower boiler of the horizontal return-tubular type, having a grate 6x5 feet, and operated by natural draft, and that at the completion of the test the following data have been collected:

Total water used was, 15,000 pounds; weight of coal fired in the damp state, 2200 pounds; average steam pressure, 75.3 pounds per square inch, and the feed-water temperature, 60 degrees Fahrenheit, both obtained from the quarter-hourly observations. It is assumed, for the sake of simplicity that the water was not passed through a feed-water heater before entering the boiler; but in such a case the temperature of the feed must be taken at the heater instead of at the reservoir barrel, and the subsequent calculation of the factor of evaporation based upon this temperature instead of the initial temperature at the barrel. The average temperature of the gases leaving the heating surface of the boiler was 400 degrees Fahrenheit. On reweighing the coal put aside to dry, the loss in weight due to expelled moisture was found to be eight ounces. The dry ashes resulting from the fire cleaning weighed 330 pounds.

Now, we find that 15,000 pounds of water were raised from 60 degrees Fahrenheit and transformed into steam at 75.3 pounds gage pressure by 2200 pounds of the fuel; therefore the equivalent evaporation under the actual conditions of the test was 6.82 pounds of steam for each pound of coal fired. But it is obvious that if the same quantity of heat had been applied to water at the boiling point (212 degrees Fahrenheit) instead of 60 degrees Fahrenheit and this had been transformed into steam at atmospheric pressure instead of 75.3 pounds gage pressure, considerably more water would have been evaporated.

There are 970 B.t.u. absorbed in transforming one pound of water from 212 degrees Fahrenheit to steam at 212 degrees Fahrenheit, or from a liquid into the gaseous state, at normal pressure. Referring to standard tables of the properties of steam we find the total heat in one pound of water at 60 degrees Fahrenheit to be 28, and the total heat in one pound of steam at 75.3 pounds, gage pressure, to be 1184.4 B.t.u. Subtracting the total heat of the feed water at the observed temperature from that of the steam at the observed pressure and dividing the remainder by 970 we have

$$\frac{1184.4 - 28}{970} = 1.192$$

the factor of evaporation; and on multiplying the total pounds of water used under actual conditions by this figure, the equivalent evaporation from and at 212 degrees Fahrenheit is obtained. Having found the approximate percentage of moisture in the fuel, in the manner described, it is an easy matter to find the pounds of water evaporated from and at

212 degrees per pound of dry coal.

The established standard for a boiler horsepower is 34.5 pounds of steam per hour from and at 212 degrees Fahrenheit, or, what amounts to the same thing in heat absorption, 30 pounds of water transformed from 100 degrees Fahrenheit into steam at 70 pounds gage pressure. Therefore, to express the performance of the boiler in terms of horsepower, divide the total water evaporated, from and at 212, by the number of hours, duration of the test, and the result by 34.5.

To find the pounds of coal used per horsepower divide the coal used per hour by the horsepower developed.

The fuel cost of the power per hour is in the same proportion to the cost per ton as the quantity used per hour to the ton. Assuming that we have been dealing with the short ton of 2000 pounds,

$$\frac{275\ lb. \times 400\ cents}{2000} = 55\ cents.$$

TEST SHEET.

The finished results of the test calculations should finally be brought together in something like the following order, which is perhaps the most concise and comprehensible:

Date.....19..	
BOILER TEST AT.....	
Boilers, one 100-horsepower—H.R.T. type.	
Grate 6x5 feet, area.....	30 square feet
Duration of test.....	8 hours
Fuel used.....	anth. pea coal
Price per ton.....	$4.00
Total coal burned.....	2,200 pounds
Coal burned per hour.....	275 pounds
Coal burned per hour per square foot of grate.....	9 pounds
Moisture in coal (8 ounces in 160 ounces).....	5%
Ashes (proportion of dry coal), 300 pounds.....	14.35%
Total combustible in coal (approximate).....	1,790 pounds
Steam pressure, average.....	75.3 pounds
Feed-water temperature, average..	60° Fahrenheit
Factor of evaporation.....	1.192
Total water evaporated (actual)..	15,000 pounds
Total water evaporated from and at 212 degrees Fahrenheit.....	17,880 pounds
Total water evaporated per hour from and at 212 degrees Fahrenheit.....	2,235 pounds
Horsepower developed per hour..	64.8
Horsepower developed—proportion of boiler rating.....	64.8 per cent.
Pounds of coal used per horsepower	4.24
Coal cost per hour.....	$0.55
Water evaporated (actual) per pound of coal fired.....	6.84 pounds
Water evaporated from and at 212 degrees Fahrenheit per pound of dry coal.....	8.55 pounds
Water evaporated from and at 212 degrees Fahrenheit per pound of combustible.....	9.99 pounds
Temperature of the gases leaving the boiler, average.....	380° Fah.

The efficiency of the boiler is readily calculated by comparing the evaporative results, from and at 212, per pound of dry coal, obtained in practice, with the theoretical evaporative value of one pound of the dry coal, as shown by the laboratory test.

It requires 970 B.t.u. to transform one pound of water at 212 degrees Fahrenheit into steam at the same temperature, and the test shows a performance on this basis of 8.55 pounds of steam for each pound of dry coal; or that 8293 B.t.u. were absorbed in useful work out of the total heat generated by the combustion of each pound of dry coal. Now if the laboratory report states that one pound of the dry coal was equal to generating 13,000 B.t.u., then the efficiency of the boiler would be found to be

$$\frac{8293 \times 100}{13{,}000} = 63.8\ per\ cent.$$

This, under natural-draft conditions, represents a very ordinary performance, but as high as 70 and 75 per cent. efficiency is regularly attained in the best managed plants, using forced draft to control the supply of air and using coal at about half the price stated in the foregoing.

The Generation of Power

A lecture was delivered before the Franklin Institute of Philadelphia, on the evening of November 10, by Dr. D. S. Jacobus, advisory engineer of the Babcock & Wilcox Company, and formerly of the Stevens Institute of Technology, on the above topic. In this lecture the great developments of the art within the last few years were discussed, the subject being treated from a scientific standpoint in order to compare the failings and advantages of different means of generation, and a description given with numerous lantern slides of modern power plants and of marine practice.

The type of boiler best suited for power-plant work was fully discussed, the requirements as set forth being that while the boiler should be capable of operating economically at an ordinary load it should also be capable of being driven to a capacity that is only limited by the amount of coal which can be burned in the furnace, and that it should be of a type which can be gotten under steam quickly and cut in line, either from a banked fire or from a cold state. He did not believe in adding to the water capacity to increase the thermal-storage factor to a degree which would sacrifice the ability to get up steam quickly, as an increase in the thermal-storage capacity could improve matters but little, for the conditions to be met in ordinary power-plant work compared with the ability to get a reserve boiler in on the line in the shortest possible time. The best boilers to use are those which will respond quickly, and by having a number of the boilers in the plant under steam and others in reserve the steam pressure may be maintained practically constant. To make thermal storage a material factor the steam pressure must fall, say, 25 pounds or so, and after the pressure falls the thermal storage will act against the recovery of the pressure and the rate of combustion of the fuel and the heat imparted to the boilers must be greater than with the boilers having a less thermal capacity.

The great problem in power-plant engineering is to carry economically enough reserve capacity to meet the daily peaks of the load. Then, again, there are exceptional peaks which only occur at rare intervals so that a considerable percentage of the available power may be developed only for a few hours every month, or, for that matter, for a few hours every year. It is good modern practice to drive water-tube boilers daily at double the ordinary rating during heavy-load periods. This does not mean that the boiler is driven to an overload in the sense that it is under a strained condition of running, as the rating of 10 square feet per boiler horsepower is simply a nominal one. He believed that eventually boilers would be driven harder than this in daily practice during peak-load periods, and that additional plant economy would be secured thereby. He further stated that he had demonstrated from actual tests that under proper operating conditions boilers could be driven safely and economically at much higher ratings than the present practice adopted during peak-load periods calls for.

The steam turbine is becoming more and more the standard for large power-plant work, both on account of its fuel economy and the low cost of attendance. The most economical fuel consumption under operating conditions that has so far been published was secured in a test with piston engines where a kilowatt-hour was turned out of the station for each 25,000 B.t.u. contained in the fuel. The plant referred to is the Redondo plant of the Pacific Light and Power Company, of California. The fuel was California crude oil. The load curve had two high peaks and there was a lay-over period of 4½ hours per day during which the entire plant was shut down. The 25,000 B.t.u. represent the heat of combustion of the oil used per kilowatt-hour net electrical output for the entire fifteen-day period during which the test was run. It is a fact worthy of note that this result approaches that to be expected for the plant economy of large gas engines, for the class of service considered.

While no results for plant economy as good as the above have been published for steam turbines, it is only fair to say that the figures for water consumption for turbines show that better than this economy can be secured under uniform load conditions.

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Power and The Engineer

Editorial

Common Sense Coal Analysis

The main object of a coal analysis should be a determination of the "free-burning carbon," and not merely the fixed carbon; for it is common to find the behavior of the coal in a boiler bearing very little relation to the face value of the analysis. This is due to the fact that in some coals all the carbon is not free burning and, therefore, is not available for producing heat. This is a point which deserves careful study, for the real test of any substance is not in the laboratory but under the actual conditions in which it is to be used. A heat determination of any coal in a calorimeter may show the ultimate heat value if the coal were burned under ideal conditions, but such may bear only a remote relation to the actual conditions under which the coal is burned in the furnace.

Coal may contain carbon of several kinds, some of which is not free burning, but instead is in a semi-graphitic state or over metamorphosed, as the geologist would term it. Carbon in this form is found in Rhode Island coal. This may fittingly be termed "fixed carbon," for it requires a high degree of forcing to burn it.

Another point of discrepancy between the chemist's report and the actual performance as viewed by the fireman, is the condition of the ash. This may be of a fusible or semi-fusible kind, and as the coal tends to burn away to a clean ash, this partly melted ash covers part of the free-burning carbon, keeping the air from it and preventing combustion. This condition may be detected by the chemist if he is careful to note how the carbon burns away to ash—if it takes a long time to burn away to a clean ash the chances are that the action, just mentioned, is going on and will also take place in the furnace.

Such unreliability was recently illustrated by a coal which in the calorimeter test showed eighty-two per cent. of fixed carbon, but which under actual operating conditions did not produce as much evaporation as another coal containing only seventy-five per cent. carbon.

This discrepancy is now becoming to be recognized and unless the facts are squarely met the coal analysis is liable to become a jest among commercial men. There should be the most friendly and intimate relations between the chemist and the fireman, and the buyer for a large plant should not be misled by an analysis which, although intended to protect him, really misleads him into purchasing a coal which does not have all its fixed carbon in the form of free-burning carbon.

Leakage in Steam Engines

If the volume of a steam-engine cylinder up to the point of cutoff and including clearance be multiplied by the number of strokes per hour the product will be the volume which has to be filled per hour. The weight per cubic foot of the steam at the cutoff pressure can be found in a steam table, and the weight of the hourly volume determined. With a condensable vapor like steam, however, it will be found that the weight actually supplied to the cylinder, as determined by weighing the water supplied to the boiler or taken from the surface condenser, will be twenty or thirty per cent. more than that required to fill the cylinder up to cutoff the required number of times, if the acting fluid were all steam at that point.

The explanation is that some of the steam coming into contact with the piston and cylinder walls which have just been exposed to the relatively cool exhaust, is condensed and exists in the cylinder as water at the point of cutoff, so that there is a greater weight present than that of the dry saturated steam necessary to fill the volume.

Recent measurements of the variation of temperature of the containing surfaces seem to throw doubt upon their ability to take up enough heat at each stroke to produce the amount of condensation necessary to account for this "missing quantity," and it has been suggested that a considerable portion of it may be due to piston and valve leakage.

In a recent issue of POWER, George Mitchell, in the report of a test to determine the leakage of a piston valve, finds twenty-two per cent., enough to account for the ordinary missing quantity all at once. The test is not replete with numerical quantities, but deductions from those given show that the engine must have been using over sixty pounds of steam per horsepower-hour.

This is an abnormal condition, for piston-valve engines of even small sizes show much better economies than this. It is possible, of course, for an engine to wear into a condition where it would use

this amount or more, but this test was made with a newly fitted valve.

Too general conclusions should not be drawn from a test of this kind. It is admitted that a solid plug running in a hole will leak after a time. The tendency of the wear is to enlarge the hole and to reduce the plug. And wear there will be, but it is not likely to be excessive. The valve is balanced and the pressure on the wearing surfaces is light. The fact that it is balanced and is so simple often leads to its adoption when the power required to move it and the simplicity of replacing it and reboring its seat are weighed against the heavy drag and wearing pressure of an unbalanced valve and the greater complexity of an adjustable balance. These considerations have led to its extensive adoption upon locomotives.

We do not know that the missing quantity, which includes the leakage, has been found to be notably greater upon piston-valve engines than upon other types. It would be interesting to establish the true situation in this respect. Why does not somebody with the necessary facilities make a series of tests upon an engine of this type first with the valve as tight as it can be run and then with increasing amounts of clearance, keeping the load, pressure, speed and all other conditions constant, weighing the condensed steam, indicating the engine, measuring the diagrams for steam accounted for and observing the effect of the leakage upon the missing quantity as well as upon the total steam consumption. Such a test would bring out data of real value.

Value of Power Plant Records

Agitation pertaining to the question of central versus isolated steam plants goes on apace, and, while a few engineers are awake to the full significance of what the attitude of the central-station managers means, there are scores of engineers who continue to rest secure in the belief that there is no danger of their plant being supplanted by outside interests.

There are two sides to every question and the one confronting the chief engineer of the isolated plant is, can he produce a kilowatt-hour at the switchboard cheaper than the central station can do it for him? The solicitor from the central station says he can sell current cheaper than the small plant can make it and, in the majority of cases, the isolated-plant owner cannot obtain figures to prove, even to his own satisfaction, that this is not so.

The central-station solicitor is a genial fellow, persuasive in his ways, convincing in his arguments and a producer of facts from his point of view. It is but little wonder that after a few visits from such an individual, the owner of the small plant is convinced that he has been throwing away money and that current from the central station might be had at a lower cost per annum. A contract is duly signed and the equipment of the isolated steam plant, which is in many cases taken over by the central station, is dismantled. It would be a paying investment on the money tied up in the old plant if the machinery were covered with a suitable rust preventative and held for future use, as the time may come when the discarded steam plant will be required for isolated service again. Having accomplished their ends, the central-station men are satisfied; the owner of the isolated plant sits back and rubs his hands for a few months, thinking he is saving money (the awakening comes later when he discovers that it is costing more for heat, light and power than before the change), and the engineer is looking for another job, wondering the while how it all happened.

It is hardly the thing to hit a man when he is down, but the engineer who has allowed outside interests to come in and absorb his steam plant has no one but himself to blame. If he has not been able to show in dollars and cents just what it is costing to operate his plant he cannot justly blame his employer for listening to the man who can and does produce figures.

Steam-plant records and intelligent management are the only solution of the problem for the isolated-plant engineer. His competitors are gaining additional footholds each day, and just because the engineer cannot positively state how much it costs per kilowatt-hour at the switchboard in his own plant.

It is not enough for the engineer to send a report to the office with a total of the amount of coal burned for the month, the amount of current generated and the total labor expense. Such a report means nothing and is a waste of time. A properly kept record should consist of daily, weekly and monthly reports of all that goes on in the engine and boiler rooms. Such reports not only give accurate plant data from which the actual operating cost can be calculated, but enable the engineer to check one day's or week's operation with another, and this puts him in a position to detect, at the start, any leaks in the operation of the plant.

Engineers who keep a proper system of records need not worry much about the central station absorbing their plants unless their reports show that the operating costs are excessive. An instance recently came to notice of a plant where the central-station people had repeatedly tried to get a contract signed to supply current to a large office building and displace a very neat and efficient plant. Owing to a very complete system of keeping the plant records the engineer was able to show that the plant was heating the building, furnishing current and paying for the cost of operating and upkeep at a cost of 1.36 cents per kilowatt-hour. Although the current generated by this plant was sold to the tenants at the very low price of four cents per kilowatt-hour, the plant made a profit of $704.67 for the month of October over the operating and maintenance expenses.

What can be done in one plant can be done in another. If one engineer can generate electricity cheaper than the central station can sell it, so can others. The two things necessary are to operate economically and to keep proper records so that figures can be produced when called for by those higher up.

Do Your Own Thinking

The average man peruses his daily paper with the sole object of reading as much news as possible during the allotted time; he sees a mass of statements in print, accepts them merely as such, and they, being mostly of but passing interest, are forgotten shortly after the paper is laid aside. The motto seems to be quantity rather than quality. Indeed it is the exception rather than the rule to find a person carefully selecting his topics, digesting them and seriously reflecting upon them. This practice of promiscuous reading as a mere pastime has led to one of the worst habits a person can fall into —that of not thinking for himself, as a result of which he becomes only too willing to accept the statements of others rather than expend any of his own gray matter.

It would not seem strange if among the mass of current technical literature there appear some unjustifiable statements, but the man who challenges and analyzes them is really benefited, for in so doing he not only tests his own knowledge of the subject, but also opens up new lines of discussion which very often benefit others.

Again, there is another class of individuals, who, although capable of thinking for themselves, are willing to think only along certain lines; in other words, they are prejudiced. They have been trained to do a thing in a certain way and because it has served their purpose, they are willing to accept it as the best, shutting their eyes to all other methods without considering the relative merits.

To neither of these classes can the engineer afford to belong. To be successful he must be trained to think for himself; he must read for the sake of broadening his knowledge, and be always ready to consider the possibilities of anything that will increase the efficiency of his plant.

"Photography, the electric telegraph and the steam engine are the three great discoveries of the age. No five centuries in human progress can show such strides as these." Inscription on the statue to Daguerre, erected at Washington in 1890.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it.

Horsepower of Belting

What sized pulleys should be used for a 4-inch belt which is to connect two shafts running at 400 revolutions per minute and transmit 14 horsepower?

L. J. K.

A commonly used rule says: A belt 1 inch wide traveling 1000 feet per minute will transmit 1 horsepower. Expressed as a formula, it reads,

$$Horsepower = \frac{w\,v}{1000}$$

in which

w = Width of belt;
v = Velocity of travel.

Substituting

$$14 = \frac{4\,v}{1000}$$

$$v = 3666.66.$$

At 400 revolutions per minute a pulley one foot in diameter would have a rim speed of 1256 feet per minute. To have a rim speed of 3666.66 feet per minute at 400 revolutions, the diameter would be

$$\frac{3666.66}{1256} = 2.9 \text{ feet}$$

or 2 feet $10\frac{13}{16}$ inches.

Cover for Tail Rod

I have a vertical condensing engine and wish to cover the tail rod. If I take the packing out, can I put on the gland and put the cover over it and do away with the gland along with the packing and will ⅛ inch be enough clearance between the rod and the cover?

T. R. C.

Tail-rod covers are usually made with an opening at the base permitting access to the stuffing box. If desired, one could be made steam tight, but it would add to the clearance in the cylinder. The gland should not be removed as it serves as a guide to keep the rod central; ⅛ inch clearance between the rod and cover is more than enough.

Pressure on Morrison Flue

What is the allowable pressure on a Morrison furnace flue 50 inches in diameter and ⅜ inch thick?

P. M. F.

The collapsing pressure of corrugated furnace flues may be found by multiplying the square of the thickness in thirty-seconds of an inch by 1200 and dividing the result by the product of the diameter in inches into the square root of the length in inches. As no length is given in the question it is assumed to be 72 inches. Then

$$\frac{(12)^2 \times 1200}{50 \times \sqrt{72}} = 407 \text{ pounds}$$

With a factor of safety of 4½ the allowable pressure would be 90.44 pounds per square inch.

Weight of Cast-iron Sphere

What must be the diameter of the mold in which to cast an iron ball which will weigh 600 pounds?

N. A. P.

Cast iron weighs 0.2604 pound per cubic inch, and 600 pounds will measure

$600 \div 0.2604 = 2304$ *cubic inches.*

The ratio of the volume of a sphere to its diameter is expressed by the formula

$$\sqrt[3]{\frac{Volume}{0.5236}} = Diameter$$

which applied in this case gives 16.4 inches as the necessary diameter of the sphere. As cast iron shrinks in cooling and an allowance of ⅛ inch per foot, or 1/96 of each dimension, is made for shrinkage, the mold for a cast-iron sphere 16.4 inches in diameter will have to be

$$16.4 + \frac{16.4}{96} = 16.57 \text{ inches}$$

in diameter.

Safe Working Pressure

Please give me the rule for figuring the safe working pressure of a steel boiler 44 inches in diameter using 6 for the factor of safety. The tensile strength of the ⅜-inch plate is 60,000 pounds per square inch.

S. W. P.

The safe working pressure of a boiler shell or drum is found by the use of the formula

$$WP = \frac{TS \times t \times \%}{R \times FS}$$

in which

WP = Working pressure;
TS = Strength of plate;
t = Thickness of plate;
$\%$ = Efficiency of longitudinal seam;
R = Radius of shell;
FS = Factor of safety.

In the question the efficiency of the joint was omitted but it is assumed to be 70 per cent. Then,

$$\frac{60{,}000 \times \frac{3}{8} \times 0.70}{22 \times 6} = 119.31 \text{ pounds}$$

safe working pressure.

Expansions in a Compound Engine

How many expansions would be obtained in a compound engine having cylinders 10 and 20 inches in diameter and cutting off at quarter stroke in the high-pressure cylinder?

G. E. R.

Assuming no clearance (since you do not state it), the steam will expand to four times its original volume in the high-pressure cylinder. The low-pressure cylinder has twice the diameter, and therefore four times the area, of the high-; the steam will expand, therefore, to four times its final high-pressure volume when it fills the low-pressure cylinder, and the volume at the end of the low-pressure stroke will be

$$4 \times 4 = 16$$

times the volume at the instant of cutoff.

Mean Effective and Terminal Pressure

With an initial pressure in the cylinder of 100 pounds per square inch and a cutoff at ¼ stroke, what would be the mean effective and terminal pressures in the cylinder, allowing nothing for clearance or back pressure?

C. W. F.

The mean effective pressure of expanding steam is the mean pressure minus the back pressure. Neglecting clearance condensation and back pressure above that of the atmosphere the mean pressure of steam at 100 pounds gage pressure expanded four times will be

$114.7 \times 0.582 = 66.7$ *pounds absolute.*

Subtracting the atmospheric pressure the mean effective pressure on the piston will be

$$66.7 - 14.7 = 52 \text{ pounds.}$$

Expansions in Single Cylinder

In good practice, how many expansions are allowable in a single-cylinder Corliss engine?

E. S. C.

The range of economical use of steam lies between 3 and 5 expansions for ordinary pressures.

Slide Valve Proportions

With steam ports one-half inch wide, what would be the dimensions and travel of a plain slide valve which would cut off at ½ stroke?

S. V. P.

To give full port opening the valve travel would be 3 inches and the lap 1 inch.

New Power House Equipment

What the inventor and the manufacturer are doing to save time and money in the engine room and power house. Engine room news.

Willard Horsepower Slide Rule

This rule was devised to obtain from two settings the horsepower developed by any type of double-acting steam engine. It is a time saver and eliminates errors in figuring indicator diagrams. Cylinder ratios on compound engines can be found with but one setting.

Scale *A* shows the indicated horsepower developed from 30 to 3000; scale *B* shows cylinder diameters in inches from 10 to 100; scale *C* shows the stroke of engines from 10 feet to 6 inches, part of the divisions being marked in inches and part in feet; scale *D* shows the number of revolutions per minute from 10 to 1000; the same scale also shows the piston speed in feet per minute up to 1000, and scale *E* shows the mean effective pressures from 2 to 150 pounds. The rule is used as follows:

To find the horsepower when the mean effective pressure, revolutions per minute, stroke and cylinder diameter are given—first, set the stroke on revolutions per minute; second, move the two slides together and set the arrow near the center of slide *D* on the mean effective pressure scale and then over the given cylinder diameter, find the indicated horsepower.

To find the cylinder dimensions when the mean effective pressure and indicated horsepower are given—first, set the arrow at the extreme right of scale *C* near the word Stroke on the maximum allowable piston speed for the type of engine, usually not over 800 feet per minute; second, move the two slides together until the arrow near the center of slide *D* coincides with the given mean effective pressure, and under the given indicated horsepower read cylinder diameter. The coinciding divisions on scales *C* and *D* give the stroke and revolutions per minute that can be used, not to exceed the piston speed selected.

It may be seen that there are many combinations and the best suited for the conditions can be selected at a glance. Take the following example: With a mean effective pressure of 25 pounds; revolutions per minute, 80; stroke, 5 feet; cylinder diameter, 40 inches, find the indicated horsepower.

First, set the point indicating 5 feet on scale *C* at the point indicating 80 revolutions per minute on scale *D*, which is equivalent to 800 feet piston speed per minute, as shown by the arrow at the extreme right of scale *C*; second, move the two slides together until the arrow on slide *D*, near the center, coincides with 25 pounds mean effective pressure, and over 40 inches cylinder diameter on scale *B*, read 763 indicated horsepower on scale *A*.

Assuming a mean effective pressure of 140 pounds; revolutions per minute, 100; stroke, 4 feet; cylinder diameter, 36 inches; find the indicated horsepower.

If the arrow near the center of slide *D* is used, as should be done at first in all cases, it will be found that the indicated horsepower scale does not extend far enough to enable the result to be read. In such a case use the arrow at the right end of the slide and read the result in indicated horsepower toward the left of scale *A*, adding one cipher. Thus, using the values given above and proceeding as in the first example, over the 36 inches cylinder diameter read 346 indicated horsepower. Adding a cipher to this gives 3460 indicated horsepower. This case is very unusual as it is very seldom that as high a mean effective pressure as 140 pounds is ever used. It shows, however, the large range of the rule.

Again, assume a given mean effective pressure of 55 pounds, and an indicated horsepower of 250, find the cylinder diameter, stroke and revolutions per minute.

First, assume a maximum piston speed of 800 feet per minute, setting the arrow on slide *C* at 800. This setting gives all the combinations of revolutions per minute and stroke that can be used, indicated by coinciding divisions; second, move the two slides together and set the arrow near the center of slide *D* on the mean effective pressure 55, and under 250 indicated horsepower on scale *A* the cylinder diameter will be indicated between 15 and 16 inches. Sixteen inches would be the nearest standard even diameter, so set 16 under 250, moving the two slides together. It will now be seen that the mean effective pressure has been reduced to about 51 pounds. If it is still desired to keep the mean effective pressure of 55 pounds as given, set the arrow at this value by moving slide *D*. The piston speed will now be found to be about

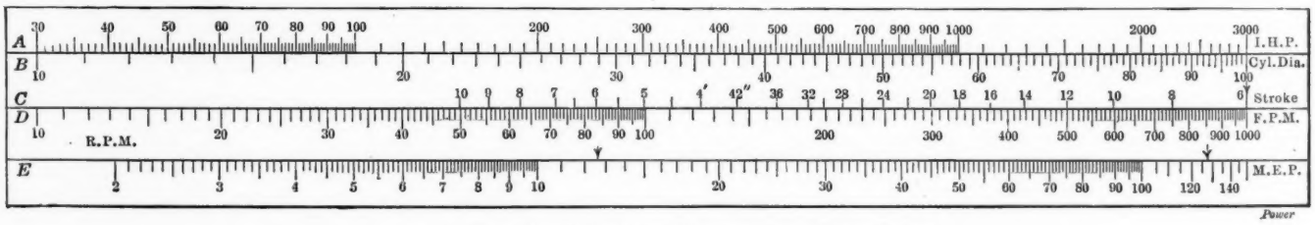


FIG. 1. THE NEW WILLARD HORSEPOWER SLIDE RULE

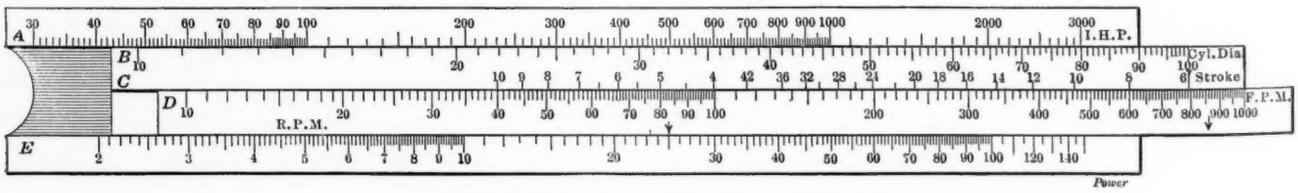


FIG. 2. FINDING THE INDICATED HORSEPOWER

745 feet per minute. This corresponds to several combinations of revolutions per minute and strokes as follows: 16x48-inch cylinder at 93 revolutions per minute; 16x42-inch cylinder at 108 revolutions per minute; 16x36-inch cylinder at 123 revolutions per minute; 16x30-inch cylinder at 148 revolutions per minute.

The usual practice in figuring compound engines is to base the calculations on the low-pressure cylinder, determining the high-pressure cylinder by a certain ratio of volumes. Thus, for compound engines to determine the cylinder sizes, etc., proceed as for a simple engine, using the proper mean effective pressure reduced to the low-pressure cylinder. After the low-pressure cylinder diameter is found and the ratio of the volumes of the two cylinders is known, to find the high-pressure cylinder diameter proceed as follows: On scale *A* beginning at 100, each division from there on can be considered as a scale of ratios; thus 200 would be a ratio of 100:200 or 1:2 and 400 a ratio of 100:400 or 1:4.

Suppose a case where the low-pressure cylinder has been found to be 40 inches in diameter and the cylinder ratio is 1:4. Set the 40-inch cylinder diameter under 400, and under 100 read 20-inch cylinder. If a 1 : 3 ratio is wanted, set 40 under 300 and under 100 read 23 plus. If 24- and 40-inch cylinders are used, the ratio would be 100.278 or 1:2.78. This is found by setting 24 under 100 and reading 278 over the 40-inch cylinder diameter.

When figuring the horsepower from indicator diagrams, it should be remembered that the rule is proportioned to give the horsepower for a double-acting steam engine, and that if the horsepower from one end of the cylinder only is desired, the result should be divided by 2, the same as when using the rule for a single-acting engine.

Accompanying the slide rule is a table giving the mean effective pressures ordinarily used for different steam pressures and different vacuums for both single and compound engines, when operating condensing and noncondensing. With this information before the user, it is a comparatively simple matter to determine the proper size of cylinder required for any condition or to determine the results of a test from a large number of indicator diagrams in a very short time.

The rule is made with a patented adjustment to take care of wear and effects caused by changes in the climate, which makes it a very desirable and efficient outfit for anyone who has any occasion to do any amount of estimating or steam-engine testing. It is the invention of L. L. Willard, 71 Broadway, New York City.

The Long Duplex Shaking Grate

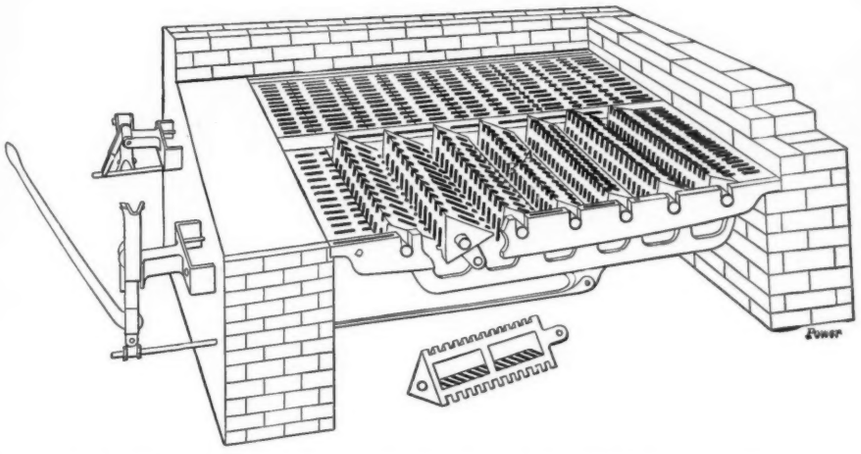
This shaking grate consists of one, two or more rows of grate bars, each having two usable sides *A* and *B* cast in one piece in the form of an inverted V or triangle.

Only one of these sides can be used at a time, for when the side *A* is in use, the side *B* is on the underside cooling off. It is claimed that this feature adds strength to the bars and prevents them from warping.

When the grate is being shaken, the side *A* of one grate bar moves opposite to the side *B* of the grate bar next to it, exerting a tremendous crushing effect on the clinker and ashes, and at the same time the clean side of the grate bar that is coming into use rakes the unconsumed fuel off of the top of the ashes, leaving the clinker to drop through into the ashpit. The illustration shows how the grate operates.

The shaking mechanism locks in both the forward and backward position, and the grates are thus held level. Suitable means are provided for any adjustment necessary to level the bars due to expansion, contraction, etc.

The grates can be placed under any boiler without altering the firebox. The only cutting necessary is a 1½-inch hole through the boiler front for the stoker rod. The grate is made by the Long Grate Bar Company, 611 White building, Buffalo, N. Y.



SHOWING DESIGN AND APPLICATION OF THE DUPLEX SHAKING GRATE

New Bayer Soot Blower for Water Tube Boilers

The accompanying illustrations show the new Bayer soot-blower system designed to be applied to water-tube boilers of the Babcock & Wilcox type.

FIG. 1. BLOWER INSTALLED ON B. & W. BOILER

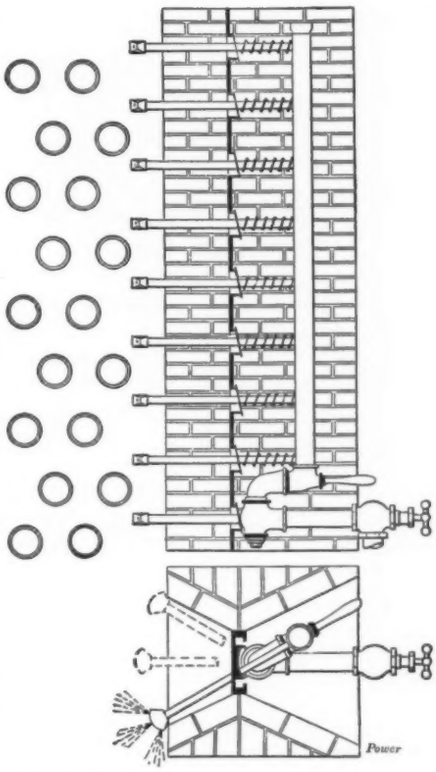


FIG. 2. SECTIONAL AND PLAN VIEWS OF BLOWER INSTALLATION

The upright headers, shown in Fig. 1, are mounted on a special brass swing joint and carry jets with three-way noz-

zles. These nozzles enter through the cleaning ports and blow across and between the tubes, sweeping the entire surface. Adjustable cover plates, the construction of which is apparent in Fig. 2, are fitted to the flue-blowing apparatus so that no cold air is admitted to the interior of the boiler setting. The removal of soot is accomplished by opening the valve wide and moving backward and forward the handle attached to the header mounted on the swing joint.

One of the features of this system, which is manufactured by the Bayer Steam Soot Blower Company, St. Louis, Mo., is that it can be applied to water-tube boilers without altering the setting or without doing masonry work of any kind. It can also be removed in a few minutes if desired.

Monarch Water Tube Soot Cleaner

This is a new soot blower designed for cleaning the tubes of water-tube boilers. The cleaner consists of a series of jets placed in the side walls, which blow all soot deposit in the direction of the draft. It is not exposed to the heat and is practically indestructible. It can be applied to any type of water-tube boiler and does not require any alterations in the setting. Owing to its simplicity there is nothing about the apparatus to get out of order or to cause trouble.

Two views of this device are shown in Figs. 1 and 2; Fig. 1 shows the soot cleaner applied to a water-tube boiler and Fig. 2 shows a top view which indicates the direction in which the steam jet is blowing. With this device in place it is simply a matter of opening a steam valve in order to clean the tubes of the accumulation of soot. This permits operating the boiler without interruption when cleaning the tubes. The device is manufactured by the Monarch Steam Blower Company, 187 River street, Troy, N. Y.

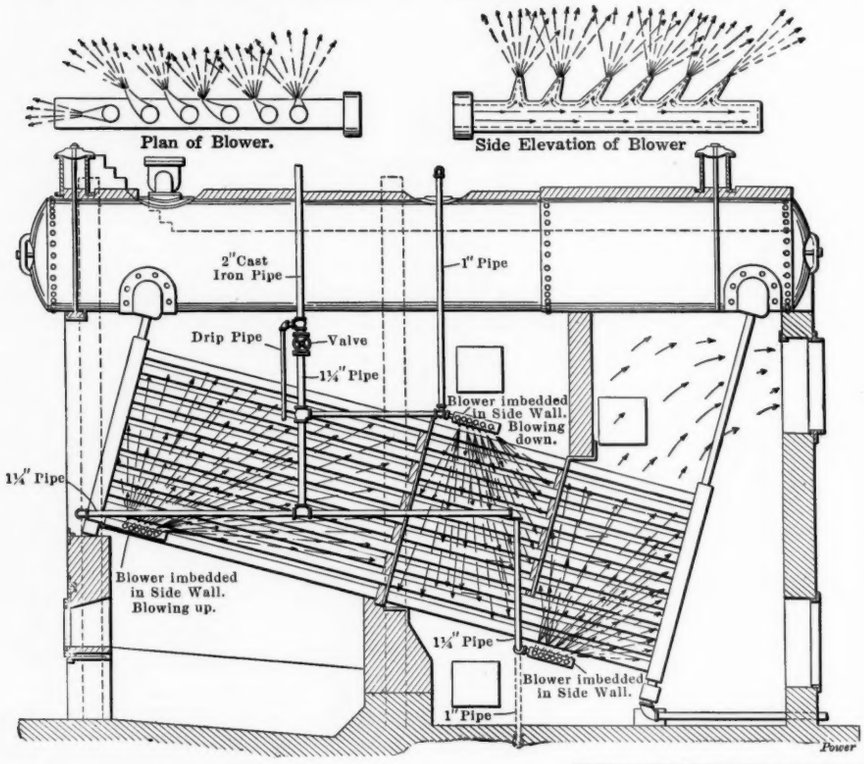


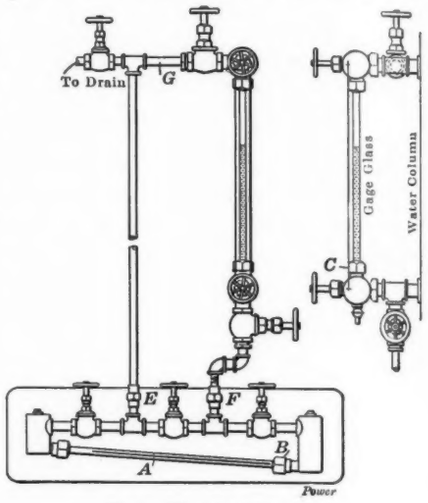
FIG. 1. SIDE ELEVATION OF TUBES

The T. & W. Water Gage

This gage is applicable to any type of boiler, its principal advantage being that it may be located at any point either in the boiler or engine room. Its special application is in connection with vertical boilers, as the gage can be placed low down on the boiler front immediately before the eye of the fireman.

The gage indicates the hight of water in the boiler by mercury in the glass *A*, as shown in the drawing, the distance from the gland *B* to the end of the mercury column always being equal to the distance from the gland *C* to the water level in the gage glass. This is accomplished by the mercury balancing the difference between the constant head of water in *E*, and the variable head *F* due to the hight of the water in the boiler.

The pipe *E* is always kept full by the condensation in the pipe *G*, any excess running back into the water column. There are no moving parts whatever inside the gage. It operates entirely by a difference of hydrostatic pressure. In operation the gage is always cold, there being no variation of temperature to break the glass.



T. & W. WATER GAGE

After the device has been properly connected up and charged with mercury it needs no further attention, and the water column can be blown out and the boiler put in and out of service without manipulating any of the valve connections.

This water gage is manufactured by McMeans & Tripp, 607 State Life building, Indianapolis, Ind.

Dennis Flanagan, th' Frenchman thet runs th' light plant, hez a wooden leg. He lost th' original when he wuz servin' in' th' Salvation Army. Sez thet it kums mighty handy when his ingin stops on th' center.

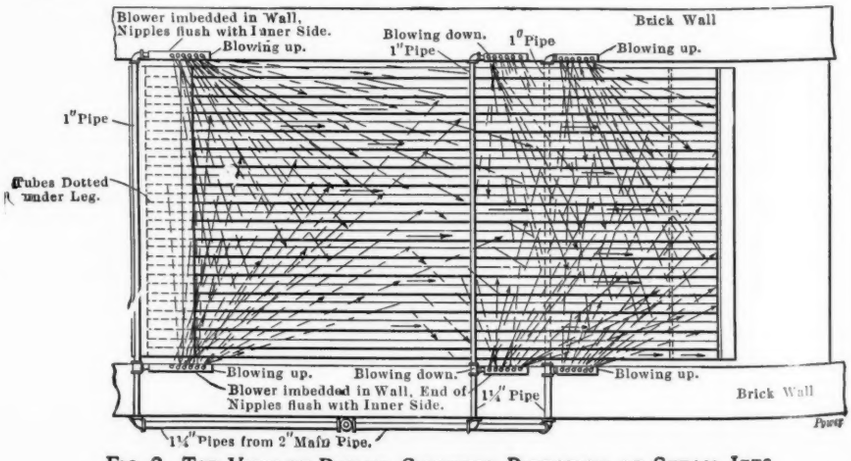


FIG. 2. TOP VIEW OF BOILER, SHOWING DIRECTION OF STEAM JETS

Ironmongers to Hold International Exposition at Budapest

Under royal protection and with the assistance of the Board of Trade of Hungary, the National Association of Hungarian Ironmongers will hold an international exposition at the Industrial palace at Budapest, in May and June of next year. Articles intended for exhibit will be transported on the Hungarian state railways at one-half the ordinary freight rate, and the committee on exhibition will take care of the insurance and the operation and representation of exhibits sent from abroad without attendance. Every exhibitor will be presented with a commemorative medal and an exhibitor's diploma, and the Hungarian government has placed diplomas, as well as gold and silver medals at the disposal of the committee. The national Hungarian trade societies and corporations will also offer awards and medals for exhibits of particular merit. Joseph Baneth, of Budapest, is in this country in the interests of the exposition and will be located at the Herald Square hotel in New York until the middle of December.

Notes on Causes of Boiler Failure

In the November 1 issue we published an article under the title, "Notes on the Causes of Boiler Failure" in which a slight typographical error was permitted to escape correction. At the top of the middle column on page 1936 the word "tension" was used in place of "compression." From the sense of the preceding text the error is perfectly obvious.

The sentence containing the error should have read, "Since in a plate that is bent, there exists a tension on one side *a*, Fig. 2, and a compression on the other side *d*, and in addition there is an initial stress of 12,000 pounds to the square inch, the resulting total stress in the joint is

$$18{,}000 + 12{,}000 = 30{,}000$$

pounds tension at *a* and

$$18{,}000 - 12{,}000 = 6000$$

compression at *d*."

The John Fritz Medal Award for 1910

On November 30 at the house of the American Society of Civil Engineers, Alfred Noble, a past president, was awarded the John Fritz medal, which was established in 1902 in honor of Mr. Fritz on his eightieth birthday. Dr. Samuel Sheldon presided and addresses were made by Isham Randolph and Dr. R. W. Raymond.

The awards of the John Fritz medal have been as follows: In 1905 to Lord Kelvin, "for his work in cable telegraphy and other scientific attainments"; in 1906 to George Westinghouse, "for the invention and development of the air brake"; in 1907 to Alexander Graham Bell, "for the invention and introduction of the telephone"; in 1908 to Thomas Alva Edison, "for the invention of the duplex and quadruplex telegraph, the phonograph, the development of a commercially practical incandescent lamp and the development of a complete system of electric lighting, including dynamos, regulating devices, underground-system protective devices and meters"; in 1909 to Charles T. Porter, "for his work in advancing the knowledge of steam engineering and in improvements in engine construction."

Gas Engine Trades Meet at Racine

At the meeting of the National Gas and Gasolene Engine Trades' Association which will be held at Racine, Wis., December 12 to 15, the following program has been announced:

"The Installation of a Mechanical Ignition System Complete," by H. F. Apple, Dayton, O.; "Does the Efficiency of a Gas Engine Depend on the Equipment?" Charles F. Kratsch, Chicago; "Salesmanship vs. Manhood," J. E. Hozier, Chicago; "Practical Electricity on the Farm," C. H. Roth, Chicago; "Gas," H. I. Lea, Chicago; "The Gasolene Engine in the Agricultural Field at Home and Abroad," George Cormack, Jr., Plano, Ill.; "Gas Producers," H. F. Smith, Lexington, O.; "Gas Engine Ignition," Otto Heins, New York City; "Gasolene Engines on the Farm," J. C. Finkbeiner, Jackson, Mich.; "Guaranteeing Gas Engine Power," C. O. Hamilton, Elyria, O.; "Comparisons of Various Methods of Testing Engines," James Tracey, New York City.

Other papers are promised by Messrs. J. C. Miller and Ferdinand Lammert, of Chicago, and others. Every effort is being made to make this a successful and instructive meeting and all who are in any way interested are cordially invited to attend. The ladies are especially invited.

PERSONAL

John A. Dent, recently with the oil pipeline service of the New York Transit Company, has been appointed instructor in mechanical engineering at the University of Illinois.

H. B. Dirks, instructor in mechanical engineering at the University of Illinois, has resigned to accept a position as assistant to the general manager of the National Machinery Company, Chicago.

John I. Rogers has opened a New York office in the City Investing building at 165 Broadway and will now use it as his main office. He is making a specialty of machine shops and power plants and of general iron and steel-works engineering. Mr. Rogers resigned from the Midvale Steel Company, of Philadelphia, about one year ago to take up professional practice and since that time has been engaged in consultation work and design along the above lines.

Charles D. Thurber, engineer of the Pepperell Manufacturing Company, Biddeford, Me., and an occasional contributor to POWER, has just celebrated his golden wedding. Although 72 years of age, he is still in active charge of this large plant, embracing steam-turbine and electric transmission as well as reciprocating engines and water wheels. His early engineering experience was gained at the Corliss works, and he is full of interesting reminscences of the younger days and the older people of American steam engineering.

SOCIETY NOTES

The Boston members of the American Society of Mechanical Engineers will hold their monthly meeting in the auditorium of the Edison Electric Illuminating Company of Boston, 39 Boylston street, on Friday evening, December 16, at 8 o'clock. Samuel B. Fowler, a nonmember, will read a paper on the subject of the "Mechanical Handling of Freight."

NEW PUBLICATIONS

"North Dakota Lignite as a Fuel for Power Plant Boilers" is the title of Bulletin No. 2 just issued by the Bureau of Mines. This bulletin describes a series of tests at the pumping plant of the United States Reclamation Service at Williston, N. D. The Reclamation Service has a large project there and had installed steam boilers with furnaces designed to burn a brown lignite that was mined on adjacent Government land.

The furnace is of the semi-gas-producer type and has an external resemblance to the so called dutch oven. The results of the tests on the lignite show that this fuel, though generally considered unsatisfactory, may be used with fair economy under boilers that generate their full rated capacity.

The tests were conducted by the Technologic branch of the Geological Survey, which is now a part of the Bureau of Mines. The authors of the bulletin are D. T. Randall and Henry Kreisinger. The bulletin will be of interest to fuel engineers, especially to those located in lignite territory. It may be obtained by addressing the director of the Bureau of Mines, Washington, D. C.

Locomotive Explodes at Altoona

On Saturday afternoon, November 19, a locomotive assisting a westbound train through Altoona, Penn., as a pusher exploded near Thirtieth street in that city. As the boiler shot off obliquely across the tracks it was struck by an incoming eastbound train, the two locomotives of which were toppled over, killing an engineer and two firemen and seriously injuring another engineer, a fireman and a brakeman. The crown sheet came down and the explosion was very evidently due to the always disastrous attempt to make steam without water.

NEW INVENTIONS

Printed copies of patents are furnished by the Patent Office at 5c. each. Address the Commissioner of Patents, Washington, D. C.

PRIME MOVERS

ROTARY ENGINE. Andrew Renik, Kenosha, Wis. 975,637.

ROTARY ENGINE. George B. Seitz, Hammond, Ind. 975,643.

THERMODYNAMIC MOTOR. Philip K. Stern, New York, N. Y. 975,651.

HYDRAULIC POWER-TRANSMITTING APPARATUS. Carlton R. Radcliffe, New York, N. Y., assignor, by mesne assignments, to the Scientific Research Company, New York, N. Y., a Corporation of New York. 975,795.

INTERNAL COMBUSTION ENGINE. Carlton R. Radcliffe, New York, N. Y., assignor to the Scientific Research Company, New York, N. Y., a Corporation of New York. 975,796.

INTERNAL COMBUSTION ENGINE. Thomas Vritch, Dumont, N. J., assignor to the Scientific Research Company, New York, N. Y., a Corporation of New York. 975,809.

AIR MOTOR OR WINDMILL. Otte E. Sill, Los Angeles, Cal. 976,003.

GAS ENGINE. Jesse B. Brown, Belding, Mich. 976,034.

TURBINE. Calvin W. Wellman, South Boardman, Mich., assignor to Hattie M. Wellman, Oshkosh, Wis. 976,109.

BOILERS, FURNACES AND GAS PRODUCERS

SMOKE CONSUMER. John Rose Blaik, Montreal, Quebec, Canada. 975,391.

BURNER. James Edward Flitcroft, Ocean Grove, N. J., assignor to Otto Bernz, Newark, N. J. 975,518.

SMOKE CONSUMER. John S. Green, Philadelphia, Penn. 975,688.

STEAM BOILER. Willard S. Tuttle, Philadelphia, Penn. 975,736.

FURNACE HEAD FOR GAS FURNACES WITH CHANGING DIRECTION OF FLAMES. Bruno Versen, Dortmund, Germany. 975,738.

CRUDE-OIL BURNER. George C. Yale, Boynton, Okla. 975,740.

FURNACE STRUCTURE. James Eggins, Ottawa, Ontario, Canada. 975,754.

BOILER FURNACE. Gustav de Grahl, Zehlendorf, near Berlin, Germany. 975,763.

BOILER. William F. Sellers, Wilmington, Del., and Charles J. Davidson, Milwaukee, Wis., assignors to Edge Moor Iron Company, Edgemoor, Del., a Corporation of Delaware. 975,897.

UNDERFEED STOKER. Paul L. Crowe, Jersey City, N. J. 976,049.

APPARATUS FOR GENERATING MOTIVE FLUID. George B. Hayes, Denver, Colo. 976,077.

HOLLOW WATER-HEATING GRATE. Ludwig Kaufman, New York, N. Y., assignor of one-half to James Murray, New York, N. Y. 976,080.

BOILER. William F. Sellers, Wilmington, Del., and Charles J. Davidson, Milwaukee, Wis., assignors to Edge Moor Iron Company, Edgemoor, Del., a Corporation of Delaware. 976,103.

OIL BURNER. William A. Stephens, Lawton, Okla., assignor of one-half to James M. Powers, Lawton, Okla. 976,105.

POWER-PLANT AUXILIARIES AND APPLIANCES

AIR PUMP. Gregory J. Spohrer, Franklin, Penn. 975,473.

OIL BURNER. Edwin W. Tucker, San Francisco, Cal. 975,482.

VALVE. William L. Hamilton, Bangor, Mich. 975,524.

PROPELLER TURBINE PUMP. Ernest K. Hood, Indianapolis, Ind. 975,526.

MOTOR SUCTION PUMP. William H. Keller, Philadelphia, Penn., assignor to Keller Manufacturing Company, Philadelphia, Penn., a Corporation of Delaware. 975,532.

CONDENSER. David G. Galbraith, Mineral Wells, Tex., assignor to Nannie L. Galbraith, Mineral Wells, Tex. 975,612.

CARBURETER. Walter H. Potthast, Manning, Iowa. 975,635.

CARBURETER. John H. Koontz, Culver, Ind. 975,696.

REDUCING VALVE. John H. Derby, New York, N. Y., assignor to General Fire Extinguisher Company, New York, N. Y., a Corporation of New York. 975,838.

VALVE REGULATOR. Thomas W. Wilkins, East Randolph, N. Y., assignor to Ziermore Regulator Company, Johnsonburg, Penn., a Corporation of Pennsylvania. 975,915.

CENTRIFUGAL PUMP, CONDENSER AND COMPRESSOR. Edmund Scott Gustave Rees, Wolverhampton, England. 975,997.

PISTON PACKING. Hugh S. Studdert, Seattle, Wash. 976,007.

VALVE. John C. Thompson, Belmont, Cal. 976,010.

GAGE GLASS. Fred R. Bispham, Bemidji, Minn. 976,030.

VALVE FOR STEAM TRAPS AND THE LIKE. Arthur E. Duram, Chicago, Ill. 976,055.

VALVE. Elias L. Grooms, Gulfport, Miss. 976,070.

LUBRICATOR. Frederic Charles von Haxthausen, St. Petersburg, Russia, assignor to Flotteur Gesellschaft mit beschraenkter Haftung, Berlin, Germany.

ELECTRICAL INVENTIONS AND APPLICATIONS

ELECTRIC FURNACE WITH MAGNETICALLY ROTATED CHARGE. Henry Noel Potter, New Rochelle, N. Y., assignor to Geo. Westinghouse, Pittsburg, Penn. 975,571.

ELECTRIC CABLE JOINT. Wilbur O. Wilson, Chicago, Ill. 975,592.

ARC LAMP. Tito Livio Carbone, Charlottenburg, Germany. 975,935.

ELECTRODE FOR REVERSIBLE GALVANIC BATTERIES. William Morrison, Des Moines, Iowa. 975,981.

ALTERNATING-CURRENT CONTROLLING APPARATUS FOR HYDRAULIC ELEVATORS. David L. Lindquist, Yonkers, N. Y., assignor to Otis Elevator Company, Jersey City, N. J., a Corporation of New Jersey. 976,130.

MAGNETO ELECTRIC GENERATOR. Gottlob Honold, Stuttgart, Germany. 974,967.

ELECTRIC COUPLING AND SWITCH. Reinhold H. Wappler, New York, N. Y., assignor to American Cystoscope Makers, Inc., New York, N. Y., a Corporation of New York. 975,090.

ELECTRIC BAKING OVEN. James I. Ayer, Cambridge, and Horace B. Gale, Natick, Mass., assignors to Simplex Electric Heating Company, Cambridge, Mass., a Corporation of Massachusetts. 975,107.

ELECTRICAL CONNECTOR. James J. Burns, Worcester, Mass., assignor to W. H. Leland & Co., Worcester, Mass., a Corporation. 975,118.

NERNST LAMP BODY. Otto Foell and Max Harris, Pittsburg, Penn., assignors, by mesne assignments, to Nernst Lamp Company, Pittsburg, Penn., a Corporation of Pennsylvania. 975,126.

CIRCUIT BREAKER. Ford W. Harris, Wilkinsburg, Penn., assignor to Westinghouse Electric and Manufacturing Company, a Corporation of Pennsylvania. 975,421.

POWER PLANT TOOLS

WINCH. Frederick Metcalf and John E. Carson, Cleveland, Ohio, assignors to the Chase Machine Company, Cleveland, Ohio, a Corporation of Ohio. 975,559.

WRENCH. John H. Ferguson, Dayton, Ohio. 975,609.

WRENCH. Walter F. Bailey, Los Angeles, Cal., assignor of one-half to Mitchell S. Mickelson and Andrew P. Jensen, Los Angeles, Cal. 975,671.

ENGINEERING SOCIETIES

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Pres., George Westinghouse; sec., Calvin W. Rice, Engineering Societies building, 29 West 39th St., New York. Monthly meetings in New York City.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Pres., Dugald C. Jackson; sec., Ralph W. Pope, 33 W. Thirty-ninth St., New York. Meetings monthly.

NATIONAL ELECTRIC LIGHT ASSOCIATION

Pres., Frank W. Frueauff; sec., T. C. Martin, 31 West Thirty-ninth St., New York.

AMERICAN SOCIETY OF NAVAL ENGINEERS

Pres., Engineer-in-Chief Hutch I. Cone, U. S. N.; sec. and treas., Lieutenant Henry C. Dinger, U. S. N., Bureau of Steam Engineering, Navy Department, Washington, D. C.

AMERICAN BOILER MANUFACTURERS' ASSOCIATION

Pres., E. D. Meier, 11 Broadway, New York; sec., J. D. Farasey, cor. 37th St. and Erie Railroad, Cleveland, O. Next meeting to be held September, 1911, in Boston, Mass.

WESTERN SOCIETY OF ENGINEERS

Pres., J. W. Alvord; sec., J. H. Warder, 1735 Monadnock Block, Chicago, Ill.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

Pres., E. K. Morse; sec., E. K. Hiles, Oliver building, Pittsburg, Penn. Meetings 1st and 3d Tuesdays.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

Pres., Prof. J. D. Hoffman; sec., William M. Mackay, P. O. Box 1818, New York City.

NATIONAL ASSOCIATION OF STATIONARY ENGINEERS

Pres., Carl S. Pearse, Denver, Colo.; sec., F. W. Raven, 325 Dearborn street, Chicago, Ill. Next convention, Cincinnati, Ohio.

UNIVERSAL CRAFTSMEN COUNCIL OF ENGINEERS

Grand Worthy Chief, John Cope; sec., J. U. Bunce, Hotel Statler, Buffalo, N. Y. Next annual meeting in Philadelphia, Penn., week commencing Monday, August 7, 1911.

AMERICAN ORDER OF STEAM ENGINEERS

Supr. Chief Engr., Frederick Markoe, Philadelphia, Pa.; Supr. Cor. Engr., William S. Wetzler, 753 N. Forty-fourth St., Philadelphia, Pa. Next meeting at Philadelphia, June, 1911.

NATIONAL MARINE ENGINEERS BENEFICIAL ASSOCIATIONS

Pres., William F. Yates, New York, N. Y.; sec., George A. Grubb, 1040 Dakin street, Chicago, Ill. Next meeting, St. Louis, Mo., January 16-21, 1911.

INTERNAL COMBUSTION ENGINEERS' ASSOCIATION.

Pres., Arthur J. Frith; sec., Charles Kratsch, 416 W. Indiana St., Chicago. Meetings the second Friday in each month at Fraternity Halls, Chicago.

OHIO SOCIETY OF MECHANICAL ELECTRICAL AND STEAM ENGINEERS

Pres., O. F. Rabbe; acting sec., Charles P. Crowe, Ohio State University, Columbus, Ohio. Next meeting, Youngstown, Ohio, May 18 and 19, 1911.

INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION

Pres., A. N. Lucas; sec., Harry D. Vaught, 95 Liberty street, New York. Next meeting at Omaha, Neb., May, 1911.

INTERNATIONAL UNION OF STEAM ENGINEERS

Pres., Matt. Comerford; sec., J. G. Hannahan, Chicago, Ill. Next meeting at St. Paul, Minn., September, 1911.

NATIONAL DISTRICT HEATING ASSOCIATION

Pres., G. W. Wright, Baltimore, Md.; sec. and treas., D. L. Gaskill, Greenville, O.